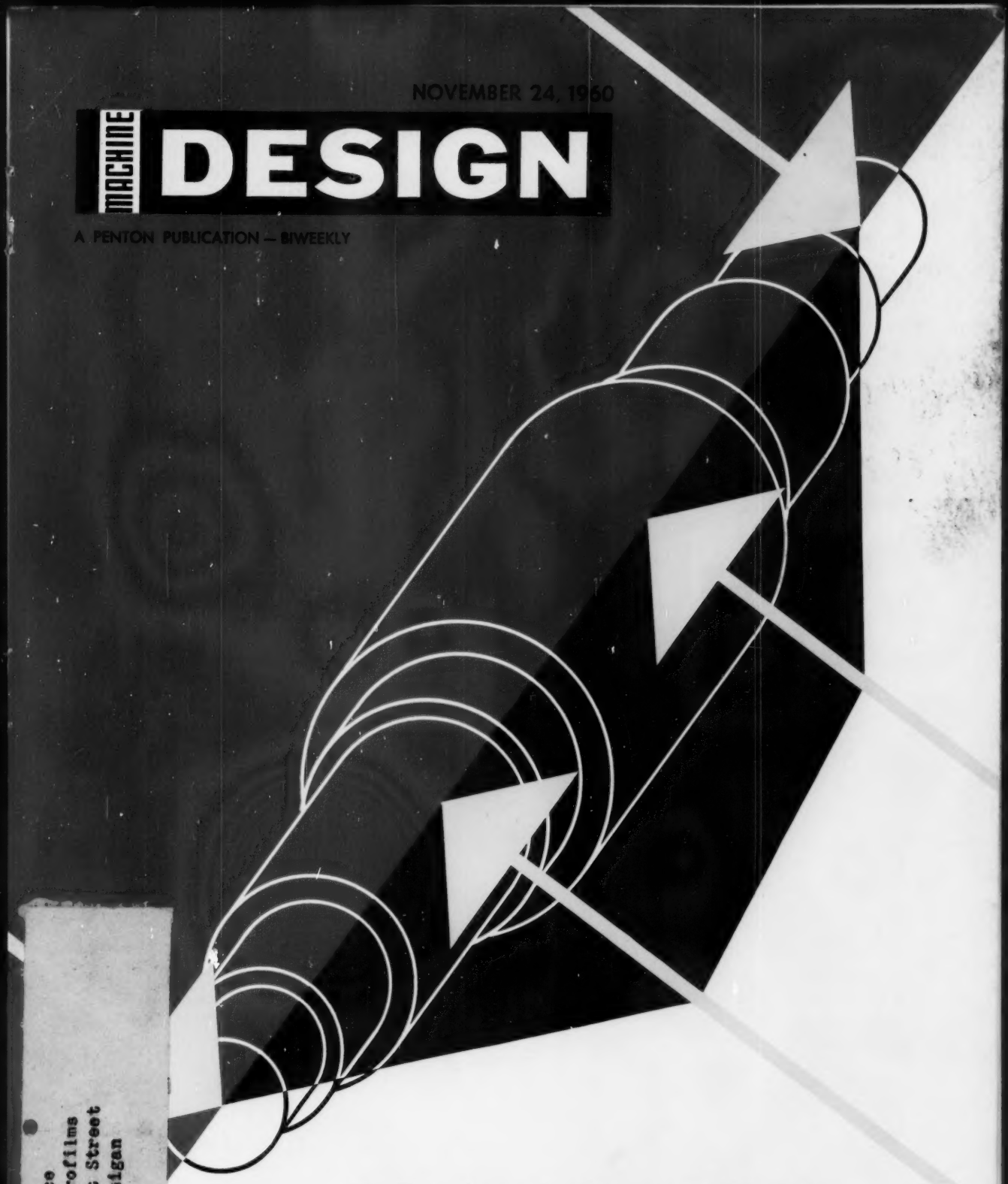
NOVEMBER 24, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Deflections in Stepped Shafts

Contents, Page 3

Mr. Stevens Rice
University Microfilms
313 North First Street
Ann Arbor, Michigan

FARNSWORTH

U.S. VARIDYNE system coordinates variable speed, multi-motor conveyors

Problem: Evinrude required coordination of many variable speed motors on unequally loaded long line conveyors. Above, one line carries partially assembled outboard engines of varying weights...on another line, finished engines flow to shipping department.

Solution: U. S. Motors field engineers suggested a U. S. VARIDYNE a/c Drive System which was selected by Evinrude on the basis of reliability and suitability to Evinrude's continuous long line production conveyors. Reliability for continuous production is assured by the use of *standard a.c. motors* throughout. VARIDYNE not only converts these fixed-speed motors to adjustable speeds, but coordinates them as well, because all motors change speeds simultaneously. U. S. VARIDYNE is available in pre-engineered packages for numerous production applications. *Write today for* VARIDYNE *Brochure F-1963.*

U.S. ELECTRICAL MOTORS INC.

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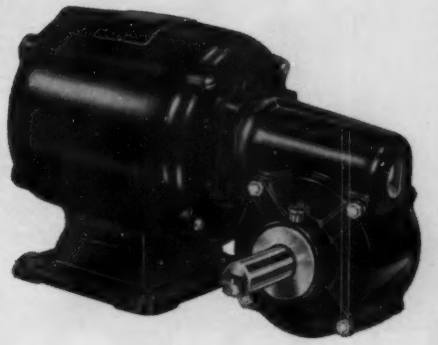
MOTOR-USER'S CASE HISTORY

"We ran accelerated life tests... selected Bodine Motors"

... HALOID XEROX INC.



"Before we selected a Bodine fractional horsepower motor to power our XeroX 914 Office Copier, our Research and Development Division conducted accelerated life tests. The results were favorable. This, plus our past experience with Bodine's dependability, made it clear that Bodine Motors should power this piece of office equipment. Also we find that Bodine's conservative rating gives us trouble-free performance even when used at full rating."

... Dr. John H. Dessauer, Executive Vice President
in Charge of Research
and Product Development, Haloid Xerox Inc.

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Bulletin describes late model business machine motor.

Here's the story of Bodine's latest model business machine motor . . . the FSE-23. It's only 2 5/16" high . . . weighs only 1 pound 11 ounces . . . and delivers plenty of power. Designed for economical, high volume production. Ask for your copy of Technical Bulletin #1034. Bodine Electric Company, 2508 West Bradley Place, Chicago 18, Illinois.

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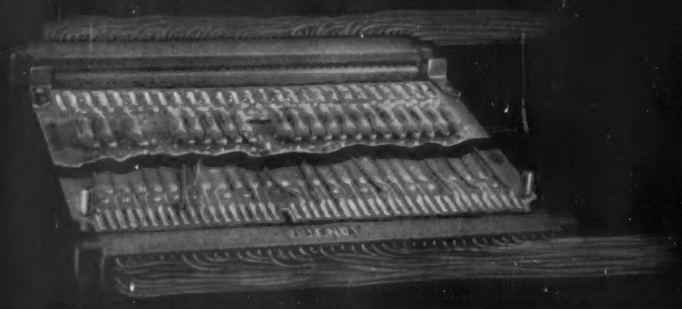
NEWEST WITH BEST FEATURES



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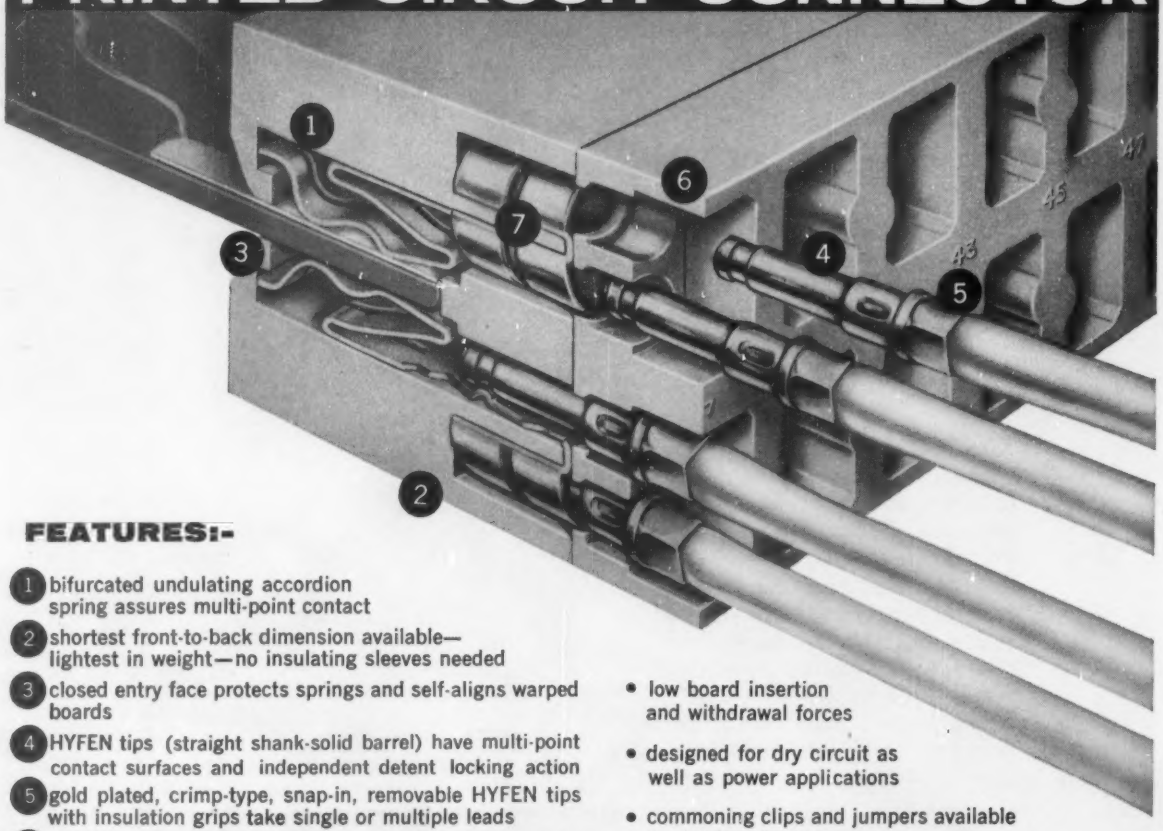

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5. gold plated, crimp-type, snap-in, removable HYFEN tips with insulation grips take single or multiple leads
6. closed entry on wire lead side prevents oversize probe damage
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- polarizing key available for any contact position for pre-notched boards

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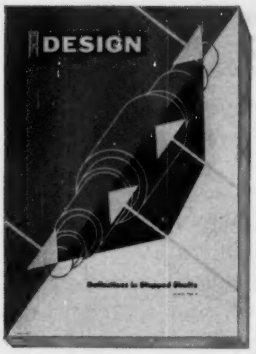

Front Cover: Bending moment diagram is kept in the dark by artist George Farnsworth as he views a stepped shaft with overhanging loads. Author Charles Bert sheds light on the subject of deflection calculations for such shafts in his article beginning on Page 128.

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EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

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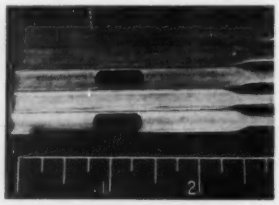
ENGINEERING NEWS

Explosive Forming Now Competitive

CANOGA PARK, CALIF.—Production parts of common metals are now being explosively formed in high quantities and at costs competitive with other methods. North American Aviation's Rocketdyne division has been using the process to form a variety of components for Atlas and Saturn rocket engines and for Hound Dog air-to-ground missiles.

A typical application described by Rocketdyne involves the production of thrust-chamber cooling tubes. Explosive forming has been used to square the ends of more than 2000 of these tubes at a savings of about $10,000 over other processes. Close tolerances have been achieved, with negligible rejections. The tubes are made of nickel and 20 CB steel.

In another application, stiffeners for a large bulkhead for the B-70 bomber are being produced at a saving of almost $500,000. In this instance, the saving is largely the result of an inherent characteristic of explosive forming—only one die is needed. Ordinarily, the stiffeners would have been formed by a drop hammer, using male and female dies.



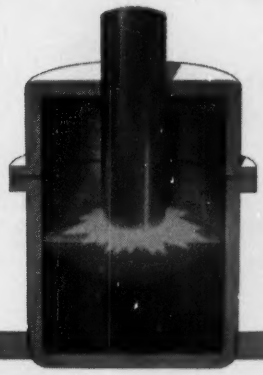
Set-up speed is another important factor that favors the explosive process. Rocketdyne recently went into production on a small rocket-engine thrust chamber only 36 hours after the decision to begin fabrication of the die.

North American has announced that Rocketdyne's technical staff and extensive explosive-forming facilities, believed to be among the most complete in the nation, would be offered to other industries for the investigation of metal-working problems.

Formerly restricted to difficult high-strength materials, explosive forming is now economical for quantity production of common-metal parts. Aluminum wing pylons (left) for the Hound Dog missile are typical. Other parts formed by Rocketdyne range in size from 0.25 in. to more than 5 ft in diameter.

WHEN MAXIMUM RELIABILITY AND MINIMUM REJECTS ARE REQUIRED

SPECIFY MIDVAC STEELS

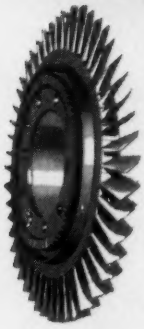


Simplified illustration of Midvac Process of consumable electrode vacuum melting.

Fine electric furnace steel electrodes are melted in water cooled copper ingot mold under vacuum of 5 to 50 microns

• Midvac Steels Are Produced By The Midvac Process Of Vacuum Consumable Electrode Melting

• Midvac super alloy and high strength steels are being used for highly critical parts in jet engines, missiles, bearings, reciprocating engines and places where high reliability is a "must". The Midvac Process of consumable electrode melting eliminates atmospheric contamination, ingot soundness is improved, segregation is reduced, workability is increased and rejects are held to an absolute minimum. M-H metallurgists are ready to help you select the right alloy to meet the specifications of your product. Write to **Midvale-Heppenstall Company**, Nicetown, Philadelphia, Pa. Subsidiary of Heppenstall Co., Pittsburgh, Pa.



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- Improvement in macro etch quality

SHAFT

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- 38% Increase In Reduction of Area
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BEARINGS

- Rejects Reduced 73%
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TURBINE ROTOR

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ROLLS

- Polished in ½ to ⅔ Time Previously Required
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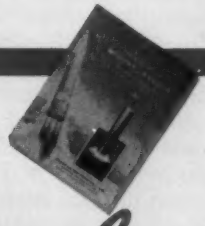

New technical data book on Midvac Process and properties of super alloy steels, melted by consumable electrode vacuum melting, now available upon request.

MH

Midvac Steels

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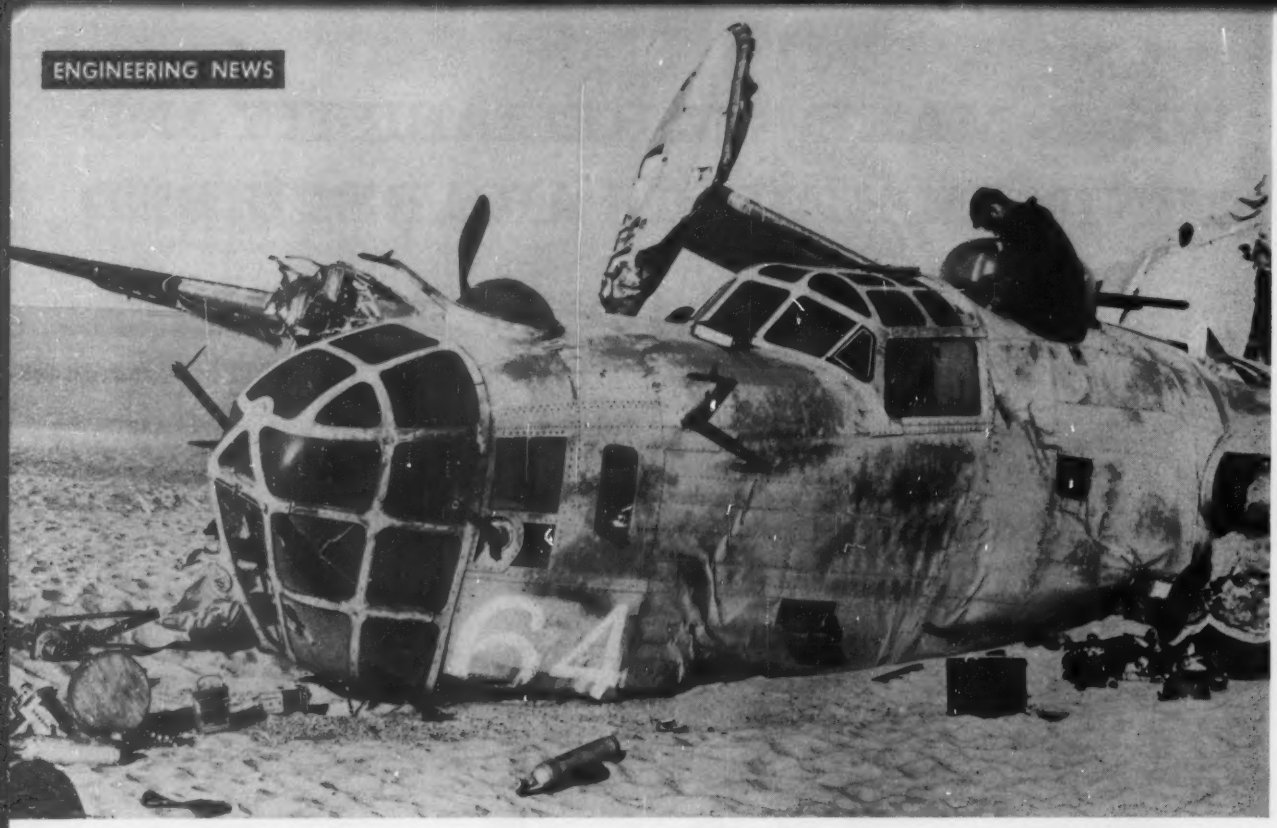
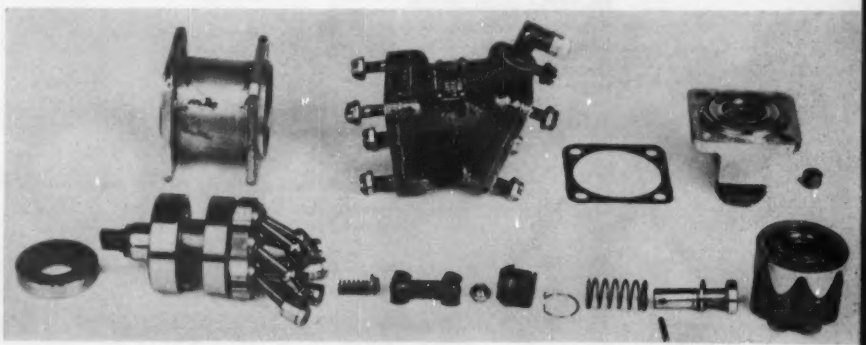


Post-Mortem on a Desert Derelict

SEVENTEEN YEARS after the B-24 bomber *Lady Be Good* glided into the Libyan Desert, its radio was still in working order, and the nose wheel, sheared off in the crash-landing, spun in every desert wind.

When Aero Hydraulics Div., Vickers Inc., Detroit, heard of the plane's discovery by an oil exploration party in late 1959, they expressed interest in conducting tests on hydraulic equipment from the derelict. Exposure of such components to the harsh desert environment since 1943 suggested that some correlation might be made with long-term missile storage and space-exposure problems.

Bright and shiny after 17 years in the open, parts of the MF-713 Vickers hydraulic motor looked like new. The shaft seal was soft and pliable, and leakage past it was not much more than ten drops per minute.



Natural Environmental Chamber

The environment of the plane during its sojourn in the North African desert was checked by the Air Force Climatic Center. Summer daytime temperature of the area reached 120 F, and winter nights could be as cold as 26 F. Humidity was in the range of 5 to 10 per cent during the day, creeping as high as 36 per cent at night. Records indicate that the plane had probably been rained on twice for a total fall of approximately 1/16 in.

Although air temperatures were

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- ☐ universal worm gear speed reducers—Catalog 2724
- ☐ parallel shaft speed reducers—Catalog 2719
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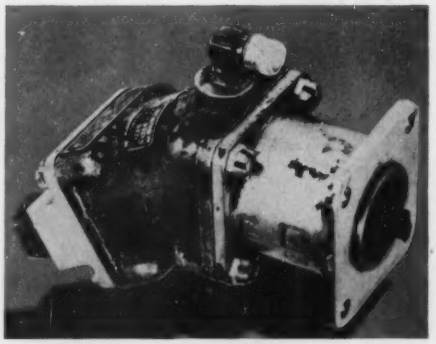
high, the desert sand and parts of the aircraft undoubtedly got considerably hotter. During the heat of the day, light-colored surface sand in the Sahara may reach 185 F; dark-colored insulated materials may attain 215 F. Probably the aluminum plane was never hotter than about 150 or 200 F.



Slight discoloration was the only deterioration found when the main system pump was inspected prior to disassembly. Given a standard production-type test, the unit met requirements of a new pump.

Double-Barrel Test Program

Early in 1960, the Air Force shipped 16 pieces of hydraulic equipment to Vickers, together with a quart of the plane's hydraulic fluid.

Many pieces of equipment were available in duplicate so the company decided that one group of items would be tested as-is, while a second similar group would be disassembled for inspection. Thus any changes made during disassembly or as-is testing could be pin-pointed.

The MF-713 Vickers bottom-turret retraction motor, as part of the second group, was disassembled in as-is condition. Because of its position at the time of the landing, all three hydraulic lines were sheared off at the unit fittings. Although the motor was entirely caked with sand, its drive shaft turned freely by hand. The sheared lines meant that the equipment was open to the atmosphere during the seventeen-year period. Upon disassembly, the motor was found to be in perfect condition, although full of sand. After reassembly, the motor functioned well and met efficiency requirements of a new unit. Leakage, however, was above specification limits because of a small scratch on the motor shaft.

Enclosed Fluid Unaffected

Preliminary tests on the fluid showed it to be slightly discolored. However, further tests showed it to be in very serviceable condition, and it is believed that only minor deterioration of the fluid resulted from its being in a closed system. A check of the plane's engine lube system showed that, even though engine oil tank-caps were tightly closed, all oil had evaporated through the breather ports.

The hydraulic system was built before the widespread application of the O-ring, so that most of the equipment was sealed with Chevron packings or gaskets. Nevertheless, as indicated by the leakage results, they were functioning well, and were still flexible and soft during the tests.

Since many of the hydraulic components have basic designs that are very similar to today's equipment, these test results indicate that in modern missile equipment, with present specifications on temperature and humidity, no standby-storage problems need arise.

The tests also gave direct correlation on certain environmental effects of long-term space exposure. Solar radiation and varied temperatures apparently will not harm space-vehicle controls.

Xenon Bulb in the Spotlight

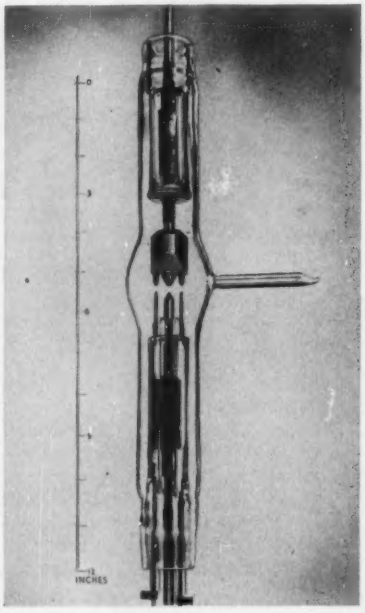
PITTSBURGH — Development of a high-brightness, multi-arc xenon bulb was made public in a demonstration to the Illuminating Engineering Society in Pittsburgh recently.

Xenon high - pressure, high-brightness bulbs will have applications in military and space fields, as well as for searchlights and projectors. Rays of the lamp can be projected for a distance of fifty miles.

The bulb differs from conventional one-arc lamp in that it has three brilliant arc discharges, spaced approximately 1/4 in. apart in one envelope. It was developed with the co-operation of U. S. Army R & D Laboratories, Ft. Belvoir, Va., by physicists of Duro-Test Corp., North Bergen, N. J.

Advantages of the xenon bulb over carbon lamps include: Maintenance-free operation; no open flame; no carbon fumes; perfect daylight color; and long life (up to 1000 hr).

Bulbs for the lamps are of quartz, which is the only transparent material with a high enough softening point. The bulbs are filled with xenon at a pressure over ten atmospheres.



Although extremely intricate, xenon lamps have many advantages. Whereas carbon-arc lights dim as carbon collects inside the tube, the new lamps remain clean and maintenance-free.

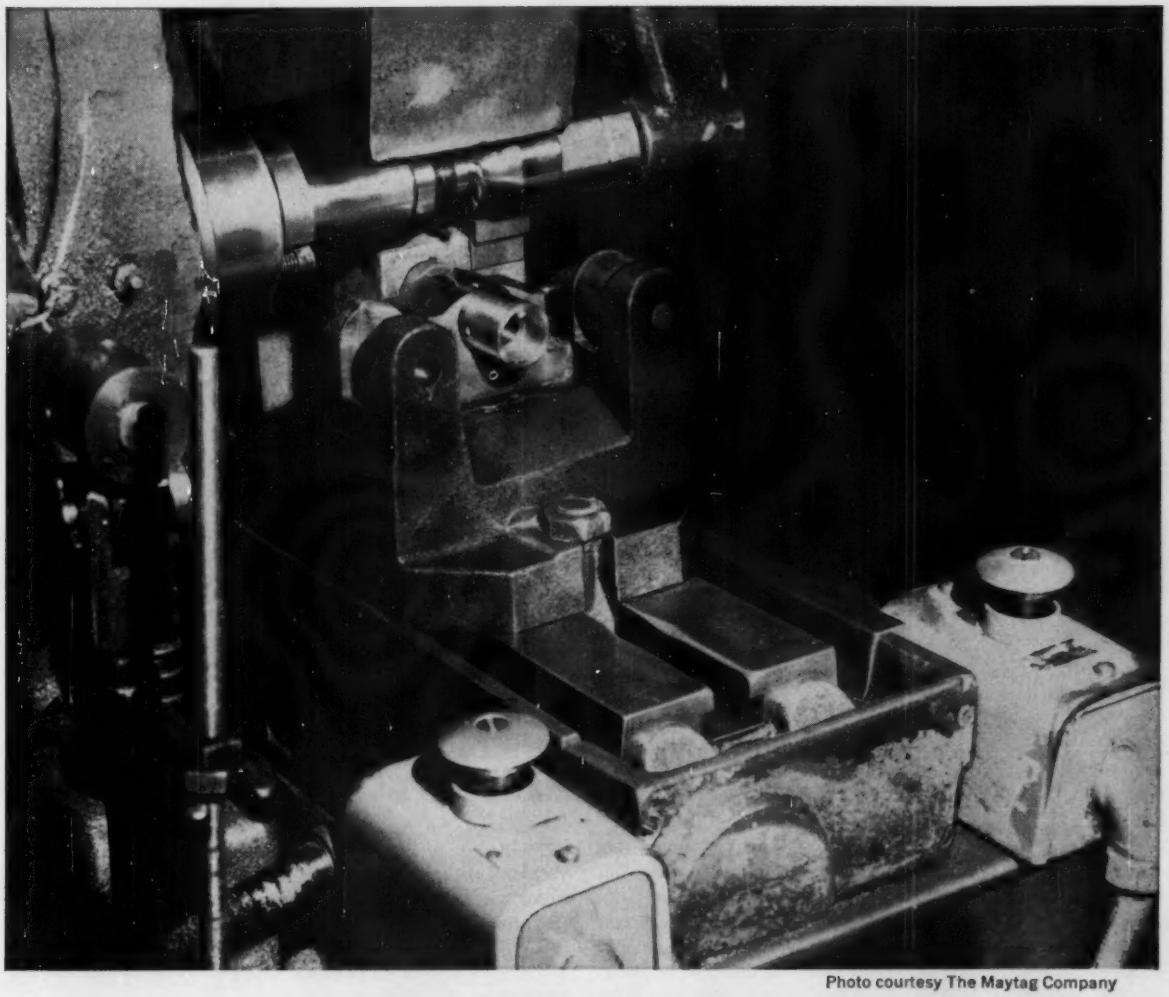


Photo courtesy The Maytag Company

Aristoloy Leaded 8620 cuts tool changes 50% on wringer drive sleeve for Maytag

Has working time been reduced? Yes.

In what way? The use of Aristoloy Leaded* has increased tool life and reduced downtime for tool changes.

Has machining been improved? Yes.

What inherent quality in the steel is responsible for improved machining? A more uniform, satisfactory microstructure provides better machining characteristics.

What operation is performed? Automatic screw machines bore, counterbore and cut off. Secondary operations include milling, drilling, internal and external grinding after carburizing.

For complete information about Aristoloy blooms, slabs, billets and bars, in carbon, alloy, stainless and leaded, call the Copperweld representative in your nearest large city—or write for NEW PRODUCTS & FACILITIES CATALOG.

*Inland Ledloy License

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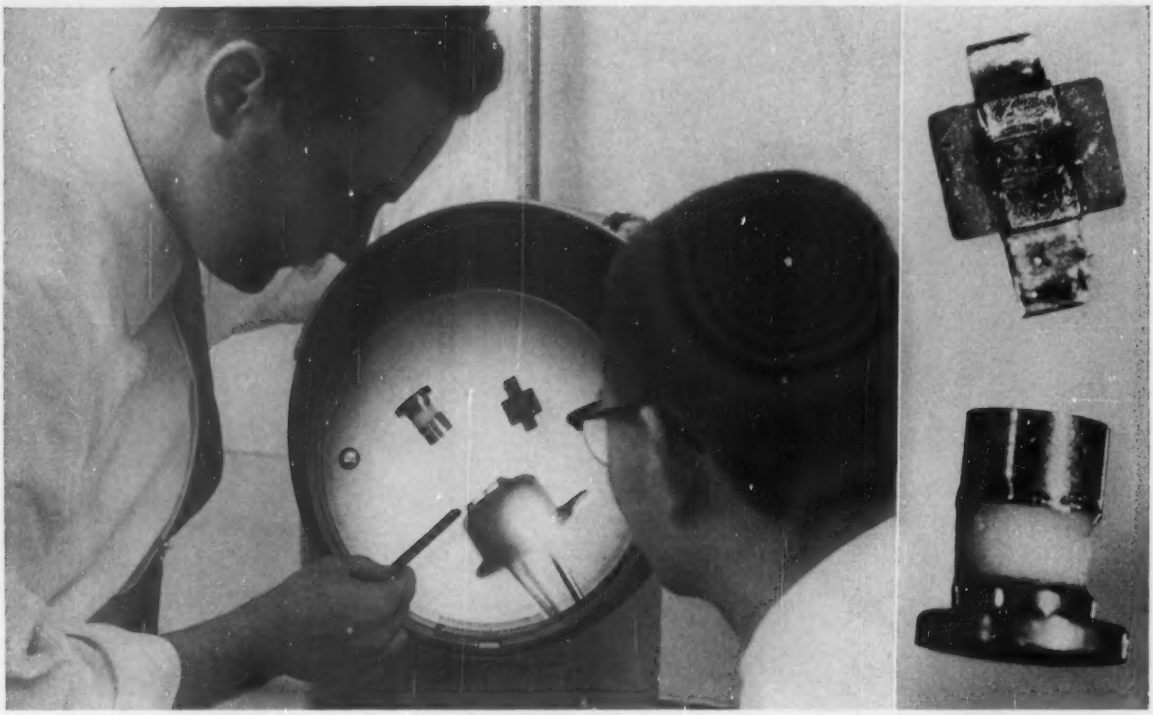
Tunnel Diodes Pick Up Speed



Binary triggers (basic computer switches) will soon be operating at speeds five to ten times faster than possible with present circuits. Two new tunnel diodes now under development at International Business Machine Corp. switch on or off in less than 0.4 billionths of a second, promise far greater reliability, and use less power than conventional models. Packaged in rivet-type and microwedge housings (shown compared with a conventional t-d package, left), the first of the two new solid-state devices is now ready for production. Key to the diodes' compactness (both rivet and microwedge are smaller than the head of a paper match) is a new fabrication method which involves an electronically monitored and controlled etching technique. The automatic process assures uniform electrical properties in every unit. The germanium is etched away until an almost microscopic pyramid remains.

Heat Triggers On-Off Magnetism

New Compound Snaps Over at "Preset" Temperature

WILMINGTON, DEL.—A new metallic substance compounded by scientists of the Du Pont Co. switches back and forth from a magnetic to a nonmagnetic state as its temperature changes. Normally nonmagnetic samples abruptly magnetize as they are heated above a "preset" point; when temperature drops, the material again becomes nonmagnetic. Slight changes in chemical structure of the compound vary the critical temperature over a range of several hundred degrees.

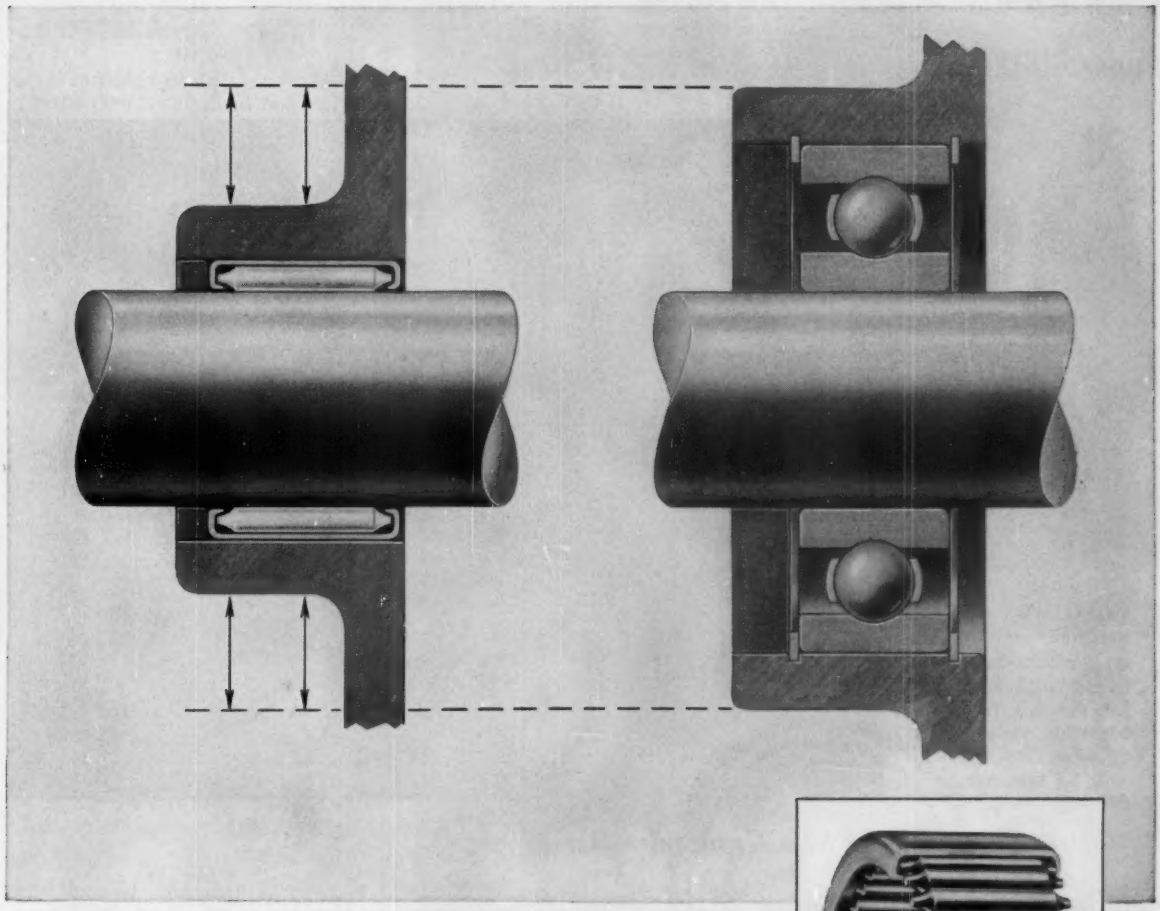
According to Du Pont researchers, the abrupt magnetic change is due to a varying distance between atoms of the material. When the distance is less than the critical minimum, inner-magnetic forces are aligned in a nonmagnetic (random) pattern; when the distance is longer than the minimum, forces line up, causing magnetism. Like other substances, the compound expands when heated. But unlike others, expansion distorts atomic dimensions and the magnetic forces shift.

The material, a chromium manganese antimonide, is expected to pave the way for better understanding of magnetism.

Discovery of the new phenomenon resulted from fundamental work on manganese compounds. These were singled out for study because they often show unusual magnetic effects. First appearing as a slight hump on one of several hundred magnetic-strength curves, temperature-induced magnetism has since been found to be a property of several substances. Key to the effect seems to be addition of chromium in proper quantities.

Still a laboratory curiosity, the phenomenon obeys some, but not all the magnetism laws:

- When it becomes magnetic, a sample decreases in size—about 0.2 per cent if the transition temperature is near room temperature.
- Maximum magnetization occurs at or just above transition.
- Transition is accomplished without hysteresis.
- At temperatures above the transition point, samples behave as normal ferromagnetic materials; magnetism decreases as temperature increases, disappearing entirely at the Curie temperature.

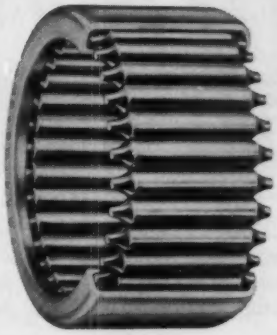


Designed for Compactness... Torrington Needle Bearings

Simpler, more compact design is possible wherever Torrington Needle Bearings are put to work in eliminating friction problems.

These outstanding bearings offer a higher radial load capacity than any other bearing of comparable size. They are more compact, lighter in weight, and are lower in unit cost. The full complement of small-diameter precision rollers insures exceptional antifriction performance and long, maintenance-free service life. The turned-in lips on the outer shell guarantee positive roller retention. Installation and assembly are fast, simple, economical.

The unmatched design and production advantages of Torrington Needle Bearings have been proved in applications ranging from office machines to automobiles, washing machines to earth-moving machinery. Give *your* product the benefit of our antifriction know-how. Write or call Torrington—maker of every basic type of antifriction bearing.



TORRINGTON NEEDLE BEARINGS FEATURE:

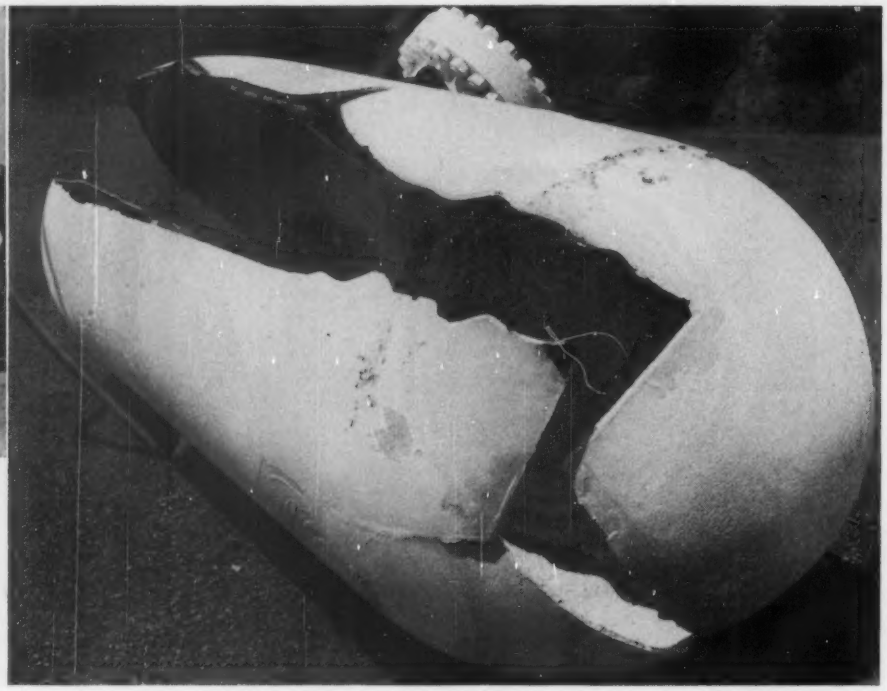
- Full complement of retained rollers
- Unequalled radial load capacity
- Low coefficient of starting and running friction
- Low unit cost
- Long service life
- Compactness and light weight
- Run directly on hardened shafts
- Permit use of larger and stiffer shafts

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY • Torrington, Conn. • South Bend 21, Indiana

Circle 410 on Page 19

Supercold Pressures New Look at Nickel Steel



Ripped open but not shattered, pressure vessel was subjected to six times design stress before it failed. Test demonstrated toughness of nickel-alloy steel at —320 F temperature.

Tests Point Way to Safe Cryogenics Design

FAIRLESS HILLS, PA.—Safe handling for cryogenic liquefied gases was demonstrated recently at U. S. Steel Corp.'s Fairless Works with tests designed to show how a pre-space-age steel can cope with today's problems.

The 9 per cent nickel alloy steel will permit safe, economical transportation and storage of gases at temperatures as low as —320 F. Many materials become brittle at low temperatures, so that containers have been heavy, bulky, and expensive. New uses under consideration for liquefied gases have been held back by the lack of a suitable container.

One proposal frequently aired has showed that liquefied natural gases, such as methane, could be shipped to areas of high fuel demand very economically—if a suitable container were available.

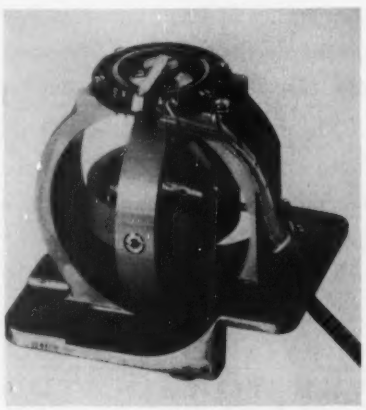
As a result of co-operative research by International Nickel, Chicago Bridge and Iron Co., and U. S. Steel Co., 9 per cent nickel alloy can now be fabricated inexpensively into containers for very low-temperature use.

Gyro Starts with a Bang

DUARTE, CALIF.—A burning charge generates gases to drive a gyroscope that may control future short-range ballistic missiles. In the hermetically sealed Pyro Gyro, a charge inside the rotor ignites electrically. Gases generated by combustion escape through holes in the periphery to provide a jet-like impulse to the rotor.

Speeds up to 36,000 rpm are attained within 0.1 second after charge ignition, and effective control performance is maintained for greater than 1 min. Drift rate for the free gyro is not greater than 3½ degrees during the minute of operation.

By agreement with Short Brothers and Harland Ltd., Giannini Controls Corp., will manufacture a wide range of both free and rate gyros that are less bulky, less expensive and more reliable than spring-driven counterparts.



Solid propellant drives a tiny gyroscope that has a maximum rotor angular momentum of 3.5 x 10^5gm per cm^2 per sec. It weighs ½ lb, ignites with a 2-w electrical impulse.

Topics

Wandering washeteria, developed by Philco Corp., is contained in a trailer. The trailer has 12 coin-operated washing machines, five dryers, and a water heater. This mobile laundry can operate wherever utility and sewer connections and official permission are available.

• • •

Fluorescence aids the mailman in Darmstadt, Germany. Stamps, made of paper containing fluorescent material, are spotted by a letter-facing machine which turns and shifts the envelope to the correct position for cancellation. An earlier model depended on the brightness tone of the stamp for positioning, and it was often confused by other stamps or printing denoting air mail, registration, or advertising.

• • •

Driest liquid since the dry martini is claimed by the Photorapid company for its ElectraMatic photocopy machine. Chemicals used in the photocopying process are contained in a sealed cartridge. They flow into the chamber when the machine is put into operation and return automatically to the cartridge, which then seals itself as soon as the machine is shut off.

• • •

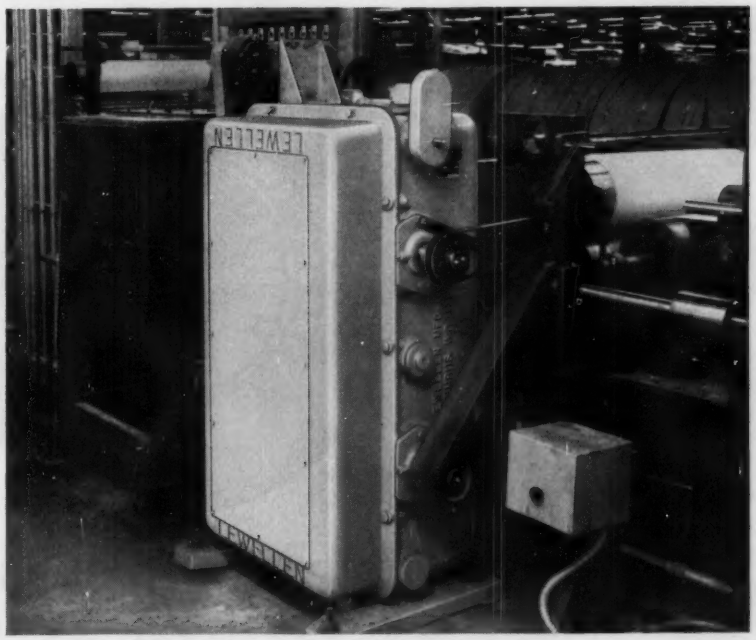
A lot of mileage—literally—can be obtained from a little fiber glass. The Saint-Gobain Co. of France recently drew a wire 4 microns in diameter and 20 miles long from one gram of glass.

• • •

Quick-thawed fish is made available to processors by a dielectric heating technique developed in Scotland. Thawing takes 15 minutes instead of 24 hours with heat generated between two metal plates charged with many thousands of volts at a frequency of about 40 million cps. Thawing does not start at the outer surface, but is even throughout.

• • •

Keeping in touch is made easier for professional men by two new devices. A pocket-sized receiver made by Dahlberg Co., a subsidiary of Motorola Inc., permits a doctor to receive messages from his hospital when he is 15 miles away. Another system, the Bellboy Personal Signaling Service, is manufactured by Bell Telephone Laboratories Div. of AT&T. Each Bellboy carrier has a number which can be dialed from his office; radio waves transmit an audible tone which sends him to the nearest telephone to get his message.



MATCH the SPEED to the OPERATION...AUTOMATICALLY

LEWELLEN
V/S TRANSMISSIONS

Machine motions, which reflect the operation, may be coupled with Lewellen Controllers to provide precisely the speeds the operation demands. For example—

This Champlain Laminator and Four-Color Press installation at the Alton Boxmakers mill.

Lewellen V/S Transmission drives Laminator at speeds that synchronize with Press, at constant web tension. Lewellen Controller couples to floating roll between machines.

Measuring ratios of machine motions will obtain proportionate speeds—or—measuring rates of motions will maintain these rates, whatever the speeds required.

Lewellen V/S Transmissions and Controllers provide stable, continuous operation automatically, by translating machine motions into correct speeds, at the right moment.

WRITE FOR CATALOG 65

LEWELLEN MANUFACTURING CO., COLUMBUS, IND.
Distributors In All Industrial Areas • In Canada—Peerless Engineering Sales Ltd., Toronto-Montreal

Circle 411 on Page 19

SOME VERY IMPORTANT ODDS . . . AND ENDS

What odds will you accept that your circuitry connections perform with absolute reliability, every time you need them? Chances are you **demand** odds approaching 100 percent in your favor—you cannot afford a compromise with precision in the thousands of terminals in your equipment.

AMP INCORPORATED has a single task: to make wire terminations so reliable that the odds on failure at the end of your wires are **zero.**

AMP makes wire terminations—15,000 solderless, snowflake-different kinds of them—for any circuit connection anywhere in the world, backed by 1800 patents issued or pending in the U.S.A. and 18 other countries. It makes the tools to apply its terminals to any size, shape or kind of wire. It makes these products in the U.S., and in Great Britain, France, Holland, West Germany, Italy, Australia, and Japan, for distribution anywhere, to any industry.

For the unabridged AMP story, write for our Selectalog and Autolog catalogs.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

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423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
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425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
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401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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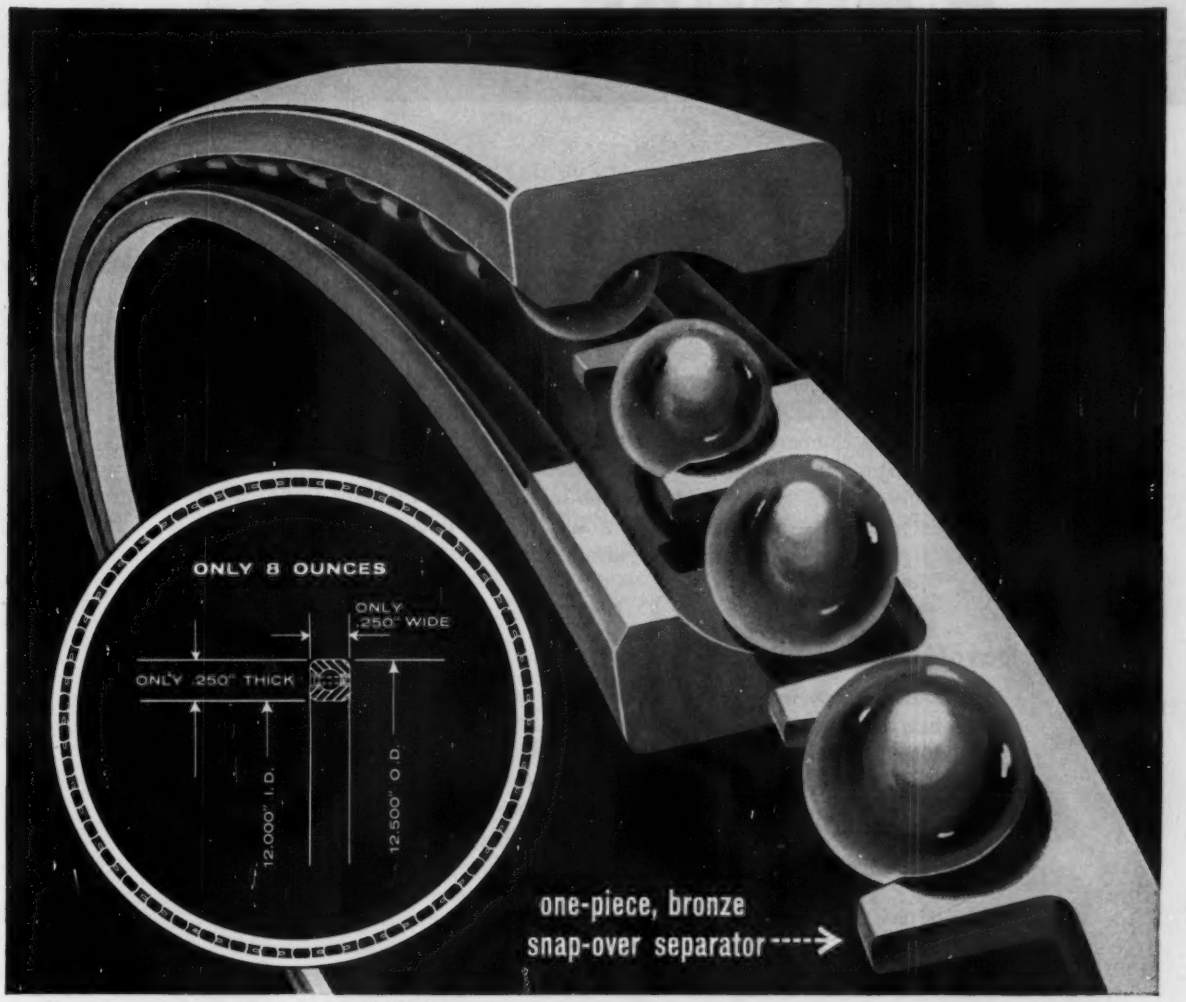


News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

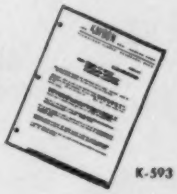
Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.



K-593

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Circle 413 on Page 19

NEWS TRENDS

reading, writing, and binary arithmetic

No longer is the computer an educational tool reserved for graduate schools. According to Prof. Bernard A. Galler, University of Michigan, it has already been used by undergraduates for homework problems. However, students need more computer logic and math courses, and this need is beginning to be recognized in progressive high schools. "Someday the computer itself may be the subject of a course in the high schools," Professor Galler states. Even today, the computer is serving as a topic of discussion and exploration for high school math clubs and advanced students.

payoff on serendipity

Research discoveries are so frequent that Boeing Airplane Co. has formed a new division, Boeing Associated Products, to handle developments with possible commercial application. Already stocked with more than 250 products and processes, BAP is already involved in electronics, electrical equipment, sensing devices, engines, tools, hardware, and hydraulic systems. According to W. E. Beall, senior vice president, "as we explore new fields, we are developing an increasing number of by-products which have uses beyond our requirements. We propose to capitalize on these developments with this new organization."

electric trucks prove their point

Field trials are over and electric delivery trucks have come through with flying colors. Tested on milk routes in Cleveland and Atlantic City, the electrics piled up all sorts of operating-expense data in their favor. For example, cost of "fuel" (gasoline vs. battery recharging) fell from 3.6 cents per mile (gasoline) to 2.5 in Atlantic City, from 7.7 to 1.5 in Cleveland. Annual maintenance cost dropped from $640 to $210, and insurance from $420 to $263 (the electrics are off when stopped and can't run away). Even tire costs favor the electrics—the smoother starts save $100 per year.

engineers to get an academy

Engineers Joint Council is forming a committee to look into ways and means of establishing a National Academy of Engineering, possibly as part of the existing National Academy of Science. Objectives of NAE would be to make available a national service, clarify the attributes of an engineer and of engineering, and formally honor a substantial number of engineers each year. First job for the EJC committee will be to decide on mechanics of the academy. How large shall it be? How shall members be selected? How should it be financed? Where should it be located?

fuel pill for a fission pile

Newest shot in the arm for the peaceful-atom program is a fuel capsule that's safe even if you carry it in your pocket. One of the most promising nuclear fuels yet developed, the capsule consists of a uranium-dioxide pellet enclosed in a coating of alumina. It does not emit dangerous fission products, even at temperatures in the 2000-2500 F range. According to AEC, the uranium combination is only a first step: Other possibilities include oxides or carbides of uranium coated with pyrolitic graphite or beryllium oxide. Key to the new ceramic coatings is their high impermeability—particles as big as an atom simply can't get through. The development may prove to be the turning point to safe, wide application of atom-powered generators.

specialist costs to climb

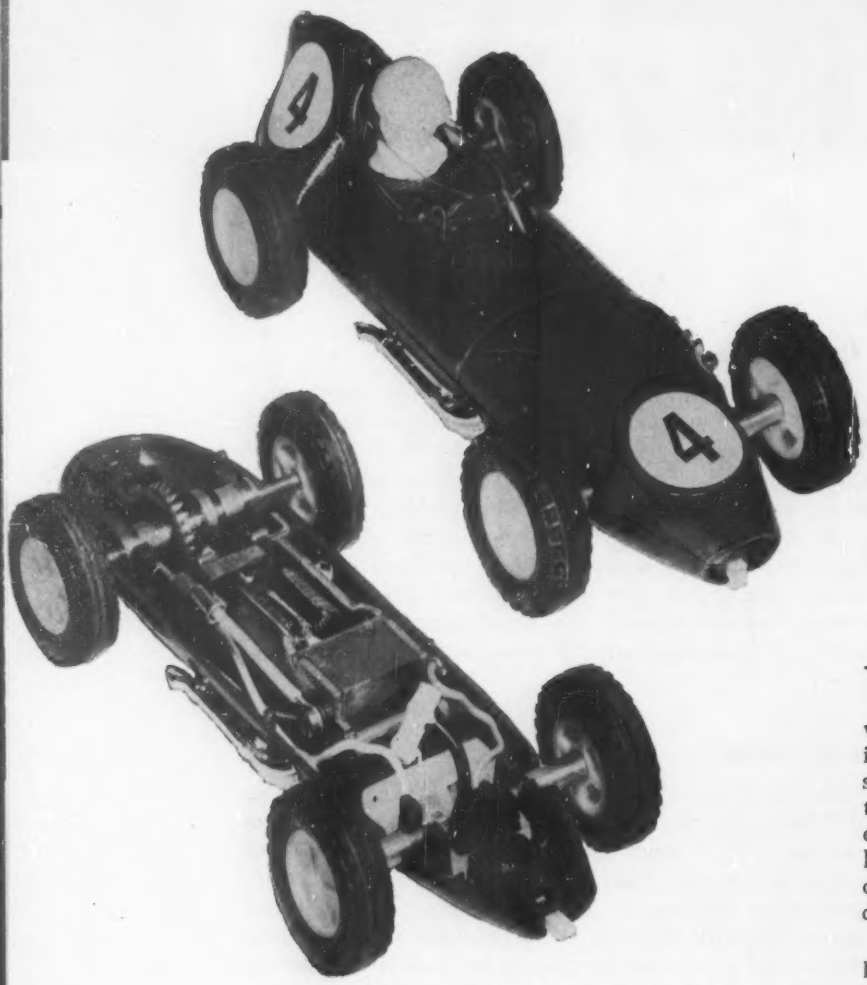
More efficient utilization of engineering personnel is the big challenge of the future, says Carl P. Spaulding, president, Datex Corp. Shortage of engineering talent will require that a much larger share of instrumentation and control systems be designed by specialist firms (like Datex). Systems-engineering outfits face a tremendous challenge in evolving organizational, marketing, and product policies that will effectively utilize available engineers. Price of engineering services will go up, and charges may be made for engineering-sales proposals.

you shouldn't take it with you?

What secrets can you ethically disclose after you change jobs? A recent survey by the Engineers Joint Council turned up data on what companies expect their ex-employees to tell and what they hope to learn from new men. Forty-four per cent of the companies responding ask new engineers to discuss "private knowledge" that will help on the new job. Fifty-four per cent define for departing engineers what information should be protected. Forty-eight per cent have trade-secret clauses in their engineering contracts.

chemical plant betters own batches

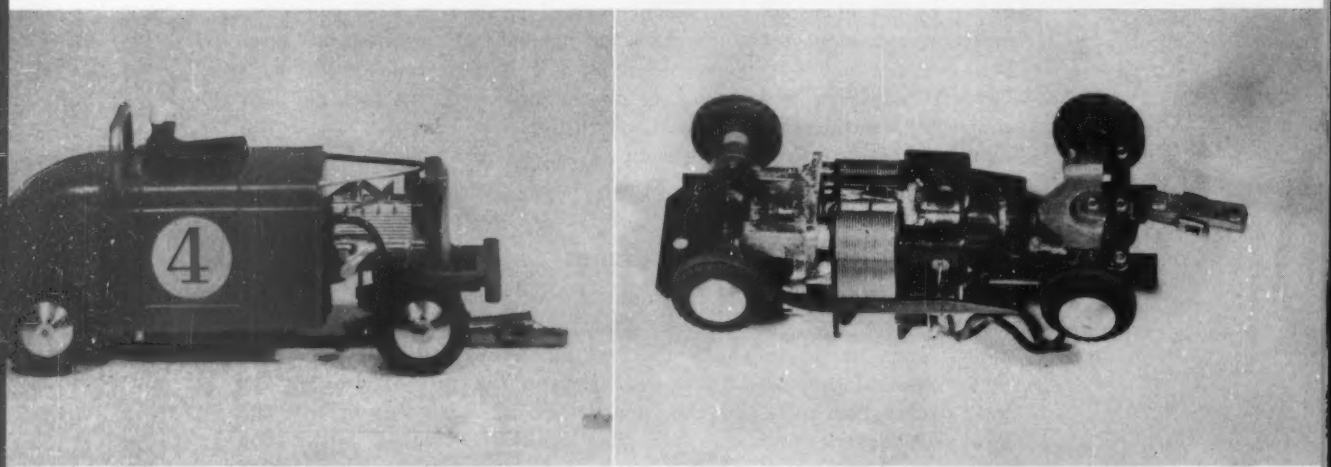
The University of Wisconsin is setting up a chemical plant that will automatically improve its own product. Financed with National Science Foundation funds, the plant will be the first fathered by statistical theory. In many chemical processes, the basic ingredients are well known, but the right combination, right temperature, and time are found only by trial and error. The experimental plant will make continuous changes in operating conditions, observe effects, calculate trends, then further explore changes which increase quality and throw out the others—all without human help.



First of the model electrics, Minimodel is a 1/30 scale model of a European racing car. The permanent-magnet motor operates on 12 v dc to produce 0.008 hp. The armature runs in sintered phosphor-bronze bearings and transmits motion to the rear wheels through a metal gear and pinion.

VYING for floor space with the electric train this Christmas, a variety of miniature electric cars will introduce the thrills of motoring to speed-hungry moppets. Toy-industry people confidently predict the electric highways will be enormously successful with a generation of children who may never have ridden a train.

There are as many design approaches to the cars as there are makers. Ranging from a simple do-it-yourself kit with an on-off battery switch to elegant scale models with adjustable speed controls, they come with as many miles of electrified



Stock Car uses an ac motor and a step-down transformer like that powering many model trains. Motor produces 1/500 hp to propel the ½-lb car, transmitting power to the rear wheels through a plastic gear and pinion assembly. A permanent magnet guides the cars along the rails (inverted train rails molded in polystyrene) through a realistic steering linkage. Individual speed controls vary the supply voltage to each track from 0 to 16 v.

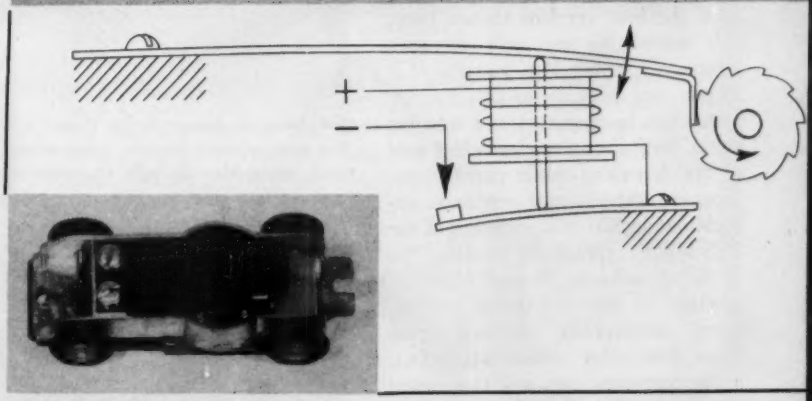
• • Table-Top Turnpikes

highway as the "motorist" can afford.

Future plans for the new toy depend largely on its reception this year, but eventually there will be dozens of model cars and trucks in all sizes and with every conceivable highway accessory.

Tracking of three of the models is accomplished with a plastic guide pin that runs in a slot in the roadway. The pins locate the car relative to the electrical lines and do away with steering mechanisms. The fourth model is guided on its track by a permanent magnet attached to the center of a life-like steering

Speedometer for Model Motoring is graduated from 0 to 120 mph (scale speed). A sliding contact breaks the supply circuit at 0 mph and cuts out the rheostat resistor at about 80 mph.

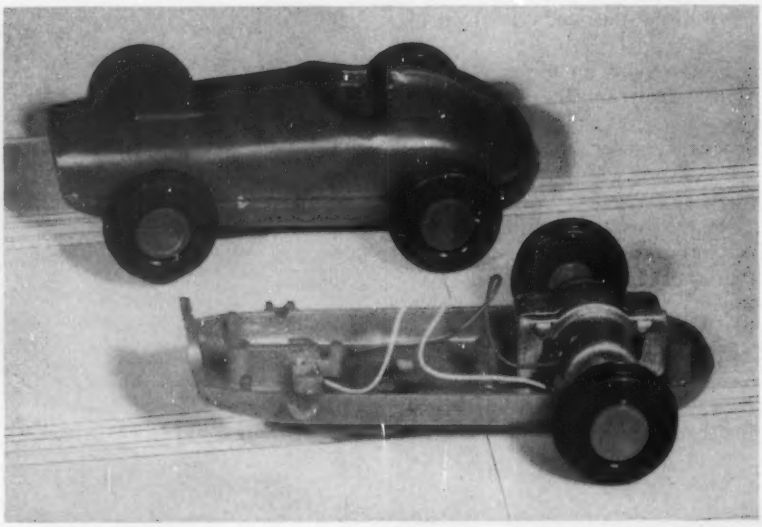


Humming around a track at 150 mph (scale speed), this 2-in. long Model Motoring car is driven by a vibrating-armature motor (like an electric bell) with only three moving parts. The car is propelled by the vibratory action of the armature turning a plastic gear on the rear axle. Engineers at Aurora Plastics Corp., West Hempstead, N. Y., spent four years designing a motor that was small enough (and economical enough) to be used in the miniature vehicles. As many as ten cars will run on a regular 3/4-amp HO power pack or transformer. Eleven plastic car or truck bodies are available for the die-cast chassis, and roadways and accessories are all built to HO scale.

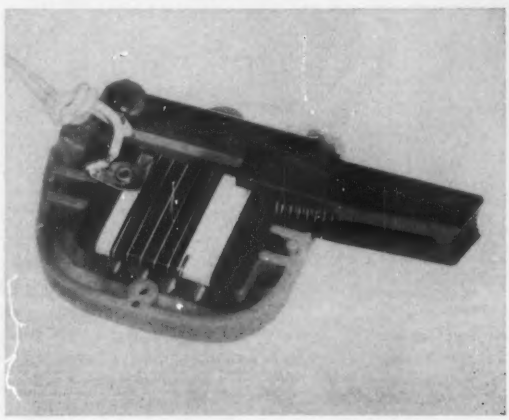
Group photo of autos available this year illustrates the diverse engineering approaches of four principal manufacturers: Model Motoring (front, left) made by Aurora Plastics, West Hempstead, N. Y.; Stock Car (top, left) by A. C. Gilbert Co., New Haven, Conn.; Auto Race Set (top, right and center) by Ungar Electric Tool Co., Los Angeles; Minimodel (front, right) by Tri-ang Toys, Ltd., Havant, England.

linkage. The magnet also serves as a center-rail current pickup.

Of the four versions shown here, it is remarkable that only one uses a Japanese motor. For, in spite of a 35 per cent duty, items like the toy motor can be imported and sold for about half the manufacturing cost of the American-made counterpart. Japanese imports now represent approximately $20 million worth of the $1.5 billion annual toy market. The U. S. toy industry, to assure itself of a share in this cut-throat market, must continually develop new ideas. Few other industries, in fact, are as cost-conscious, and there must be many who look with envy at the almost-nonexistent lead time from "development" to manufacture of a high-volume toy.



Simplicity of design is the theme of the Auto Race set. An electric motor drives the rear wheels directly, eliminating a gear and pinion. Copper electrical contacts serve also to hold the dummy front wheels off the road.



Hand controller for the Minimodel is a spring-loaded rheostat encased in a palm-sized plastic cover. For maximum speed, the handle is depressed completely to eliminate the resistor from the circuit. Releasing the hand-grip breaks the circuit.

Supersonic Transports Predicted for 1970

DALLAS—Introduction of supersonic commercial airline service in the U. S. will probably occur sometime between 1965 and 1970, according to the studied report of an informed engineer in the industry.

R. J. Patton, senior propulsion engineer at General Dynamic's Convair Div. points out that in the past, commercial transports have followed military bombers within seven to eight years. The Air Force has had considerable supersonic experience since 1954 with a number of fighter planes, and in 1956 began racking up time on the B-58.

Big Question: How Fast?

Currently, the most controversial characteristic of the proposed supersonic transport is speed. There are two very definite schools of thought on the subject: The first leans toward Mach-2 aluminum structures and the present state of the art (B-58); the second advocates Mach-3 steel or titanium construction and is based on the B-70 state of the art. There may ultimately be demand for both types of aircraft, depending on the route structure of the individual airline.

Materials, Engines Need Flying Time

Despite the military's experience with supersonic aircraft, a host of technical problems still face commercial designers:

- Materials — Characteristics and strengths of aluminum alloys after prolonged exposure to high temperature are unknown. Present data for 300 to 350-F soak temperatures are not available above 10,000 hours. For a commercial transport design, 30,000 hours would be the minimum for consideration.
- Engines—Only the J-93 and J-58 show promise. The B-70 program will eventually provide J-93 experience; the J-58 is now in a limited development program, and no vehicles are planned to provide in-flight experience.
- Flight regime—Less than 500 hours have been accumulated in flying at Mach 2. Thus, there is very little realistic knowledge available on which to predicate a supersonic-transport design.

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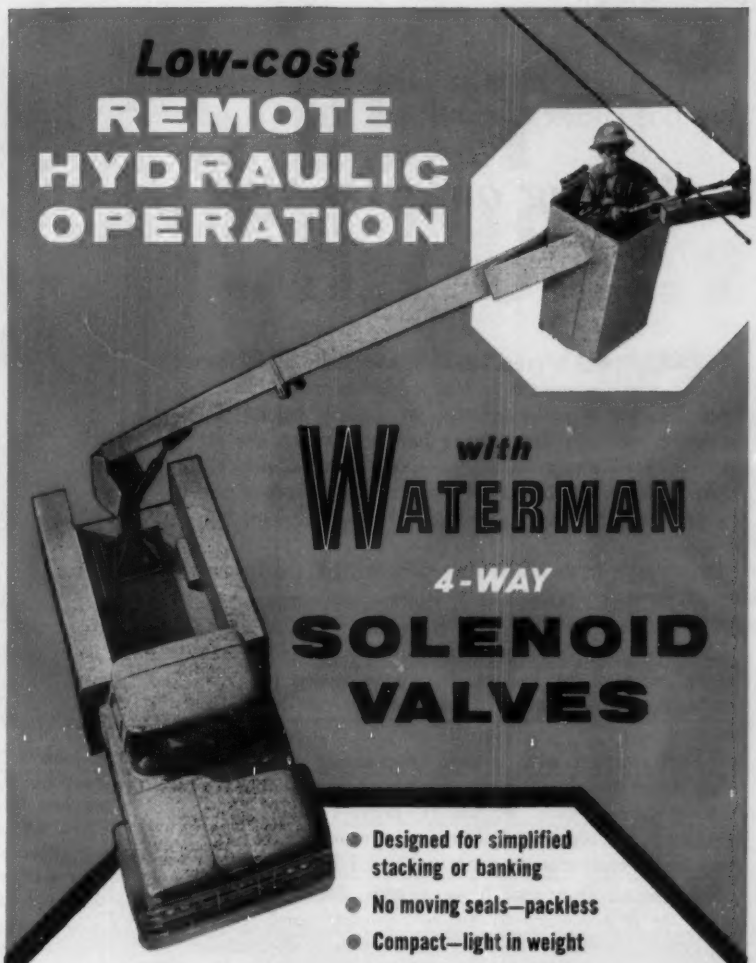

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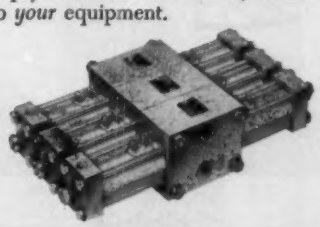
- No moving seals—packless
- Compact—light in weight

"Up high at low cost," says Pitman Manufacturing Co., makers of this new "Pelican" aerial bucket. The utility crewman aloft is in complete control of rotation, extension, and elevation—through banked Waterman 4-Way Solenoid Valves operated from push-buttons on the bucket as well as from the cab.

Waterman design is an important factor in the simplified hydraulic circuitry that helps to keep down the cost of this new unit. Packless valve design—with no moving seals and all moving parts immersed in the hydraulic fluid—is a low-maintenance selling point. Let Waterman help you build convenience, versatility, and sales advantages into *your* equipment.

Designed for simplified stacking or banking

Convenience, low cost—and versatility, too—with Waterman 4-Way Solenoid Valves. Standard kits are available for stacking or banking up to six valves. Add on later if desired, to build in other hydraulic functions. A.C. or D.C. Rated at 3000 p.s.i. ½" N.P.T.F.



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New gas burner does its

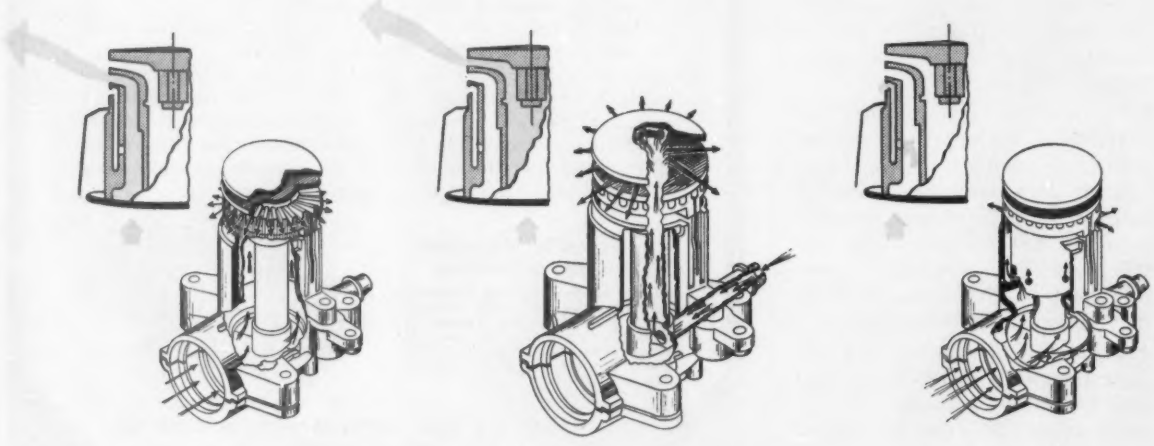
Cooking on a Cushion

A LAYER of air provides a cushion between flame and cooking utensils in a new kitchen-range burner developed by Whirlpool Corp., St. Joseph, Mich. By spreading out and distributing heat uniformly, the air cushion does away with hot spots, can indefinitely maintain even cream sauces and gravies at keep-warm temperatures without scorching, browning, burning, or lumping.

In addition to excellent heat distribution, the burner boasts three other major advantages:

- Combustion air is supplied by a blower, through tubing, into the burner head. Since air holes are not needed around the burner, it can be sealed into the combustion chamber, and food and dirt can be sealed out.
- When coupled with a new snap-acting thermostat (also developed by Whirlpool), the burner can keep cooking temperatures within 10 degrees of set temperature. Conventional burner-thermostat combinations allow temperature drifts up to 25 F.
- Because air flow can be accurately controlled, less excess air is necessary to insure complete combustion, and cooking utensils can be located closer to the flame.

Air cushion, located between flame and cooking container, balances out heat distribution, even when the burner is set at low heats. Whirlpool spokesmen point out that their new kitchen range will cook an egg in a paper plate or melt chocolate in its own wrapping without burning the plate or wrapper. Nevertheless, when set for high heats, the unit will cook as fast as any other high-speed range. This combination of high and low heats makes the new appliance the most versatile model ever developed.



Premixed fuel gas and air discharge through the burner ports in a normal manner (left). But, as in most gas burners intended for residential use, more air is needed for combustion than is present in the mixture (the premixed stream is designed "air hungry" to suppress premature ignition). The secondary-air system in the new Whirlpool kitchen-range burner has been radically redesigned: Instead of relying on air present in the combustion chamber, the burner is force-fed from a remote blower. Piped up the center of the burner head (center), this air joins the mixture stream at the outside of the burner ports. A second novel feature is the flame-retention system (MD, May 14, 1959, pp. 22-25). Part of the air-gas mixture diverts into a reservoir where it loses velocity head and burns gently just under the main ports (right). Burners of this type can operate at unusually high input rates: As the flame blows off (its discharge velocity exceeds flame-propagation rate), it is continuously reignited by the retention flame.

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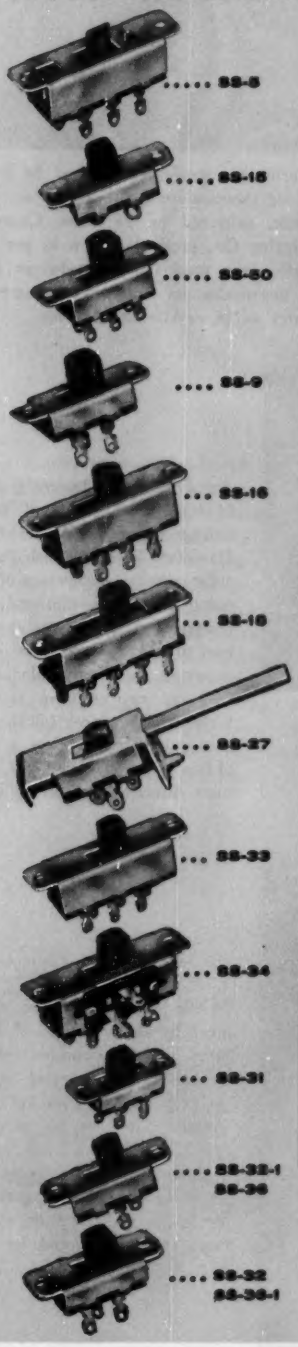

TYPE NUMBER	ACTION	SCHEMATIC (POSITION 1, POSITION 2, POSITION 3, POSITION 4)	RATINGS (U.L. Inspected) AC AMPS. @ 125 V.	RATINGS (U.L. Inspected) DC AMPS. @ 125 V.
MEDIUM-DUTY TYPES	for radio, TV, audio equipment, instruments, toys and many others.			
SS-5	DP-DT Spring-Return, No detent		0.5	0.5
SS-15	SP-ST Pushbutton, Momentary, No detent		1.0	—
SS-32	SP-DT Maintained, With detent		1.0	1.0
SS-32-1	SP-ST Maintained, With detent		1.0	1.0
SS-50	DP-DT Maintained, With detent		0.5	0.5
3-AMPERE TYPES	for line switching, appliances, power tools, lighting fixtures, etc.			
SS-9	SP-DT Spring-Return, No detent		3.0	0.75
SS-16	3-POSITION Maintained, With detent		3.0	0.5
SS-18	4-POSITION Maintained, With detent		3.0	0.5
SS-27	SP-DT Spring-Return Plunger, No detent		3.0	0.75
SS-33	DP-DT Maintained, With detent		3.0	0.5
SS-34	TP-DT Maintained, With detent		3.0 0.1	—
6-AMPERE TYPES	no larger than conventional 1-amp types, yet handle heavy-duty motorized devices with ease.			
SS-31	3-POSITION Maintained, With detent		6.0	1.0
SS-36	SP-ST Maintained, With detent		6.0	1.0
SS-36-1	SP-DT Maintained, With detent		6.0	1.0

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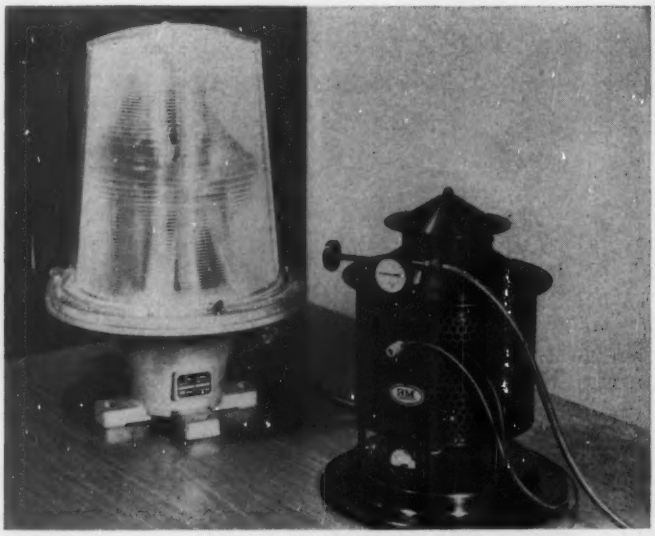
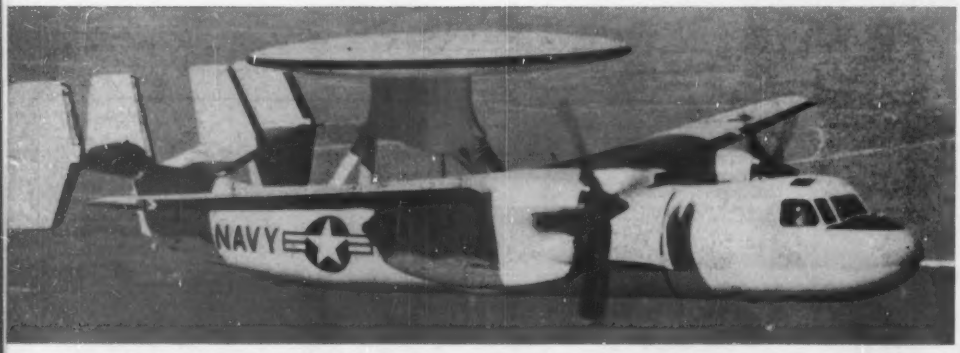
ENGINEERING NEWS

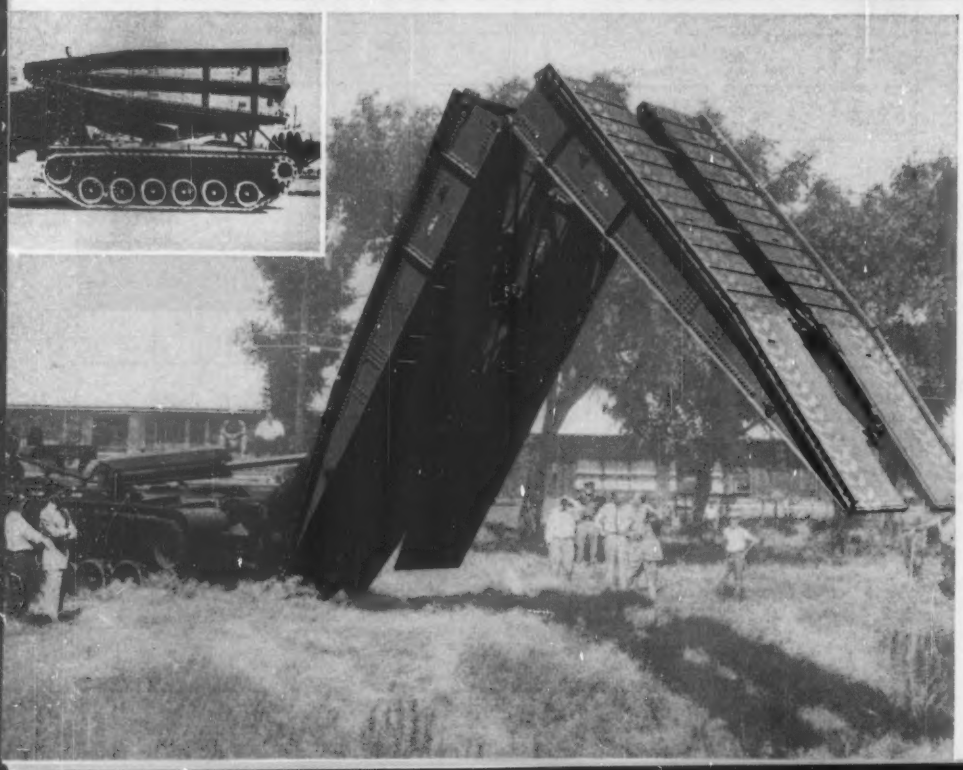
PICTURE REPORT



Powering buoys and other marine navigational aids may be one of the first practical applications for thermoelectric power sources. This 10-watt propane-fueled generator, delivered to the Coast Guard by Minnesota Mining & Manufacturing Co., produces 200 w-hr per lb of propane. Conventional batteries now used in buoys deliver about 10 w-hr per lb. Economy of thermoelectrics will also be impressive: $0.15 per kwh for thermoelectrics vs. $6 to $10 for batteries.



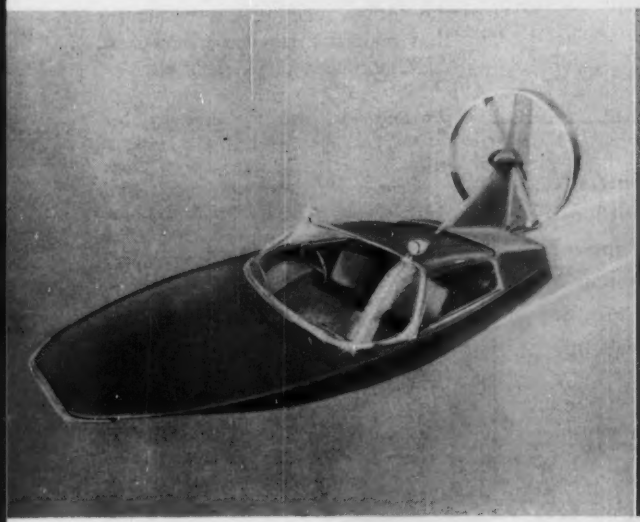
Aerodynamics apparently came in second in the design of Navy's newest airborne scout, the W2F-1 Hawkeye. To accomplish its singular mission—protection of seagoing task forces—the craft was designed around a massive complex of the most advanced radar detection gear available. Powered by two Allison T-56-A8 turboprop engines (4050 eshp each), Hawkeye carries a crew of five. It was designed by Grumman Aircraft Engineering Corp.

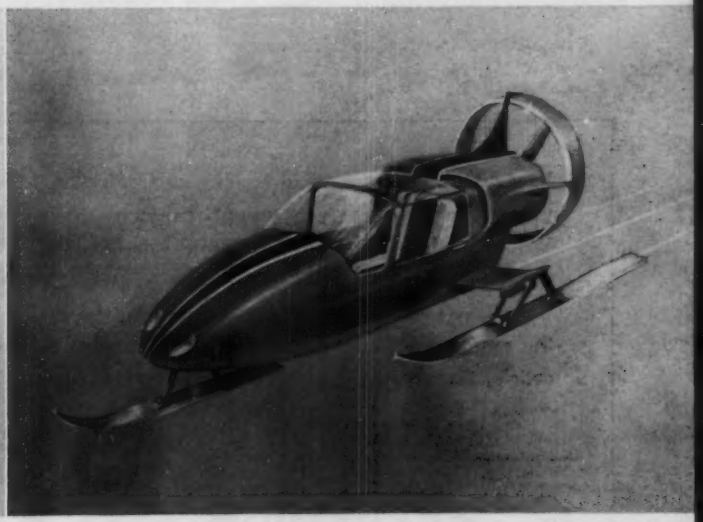


Mobile bridge launcher, developed by Army Corps of Engineers, will keep combat vehicles on the move by laying bridges up to 60 ft long over gullies or streams. The launcher, a modified M-48 Medium Tank, carries its folded bridgework piggyback. Launcher crosses over, picks up the bridge, and moves on. Equipment is manufactured by Unit Rig & Equipment Co., Tulsa.

Tailored for Lunar exploration, a two-piece aluminum suit conceived by scientists at Republic Aviation Corp. is large enough to serve as a temporary house. Tripod legs on the outside can be extended to hold the cylindrical rig upright, while the wearer rests by sitting on a perch inside. Weighing about 120 lb on earth, or a mere 20 lb on the moon, the suit contains all "conveniences" to maintain one man comfortably on an extended stroll over the moon's surface.

New family of propeller-driven vehicles, called Alphibians, will cater transportation needs of hunters, fishermen, and other outdoor enthusiasts. The 11-ft Skimak (right) travels on snow or ice, will carry from one to nine persons, depending on the model. Nordak (left) is a high-speed amphibian (snow, ice, or water), can be fitted with hydrofoils for exceptional marine performance. Designed by American Alphibian Co., Palo Alto, Calif., the vehicles have glass-fiber bodies, are powered by 65 to 165-hp engines, and weigh from 9 to 11 lb per hp.





A survey for the engineer on the fence:

You and the Unions

Part 2—Stratagem for Growth

UNIONS are making a strong pitch for the engineer: They promise to eliminate his dissatisfactions through collective bargaining, help him escape from the "mediocrity of mass employment," win his esteem as a member of an honored and dignified profession, and boost his income significantly.

Engineers attracted by such promises wonder if they can join a union and still remain professionals. On this issue, the unions themselves are divided: The two extreme points of view are championed by the American Federation of Technical Engineers (AFL-CIO) and the Engineers and Scientists of America.

To find out exactly what unions are doing to attract engineers, a Harvard task group* asked questions such as: Where do the unions stand on professionalism? What special problems are involved in unionizing engineers? When will the AFL-CIO seriously attempt to get into the act? Which of the engineering unions has the best chance to survive? This article, the second in a series, sums up the answers.

*Roger M. Atherton, Jr., S. Marc Altman, Lincoln Ames, K. Leo Ahlstedt, Albert E. Block, Jr., Ivan H. Enstrom, Jr., Richard D. Lockhart, Theophanes G. Pantazelos, John A. Smith, Robert T. Spahr.

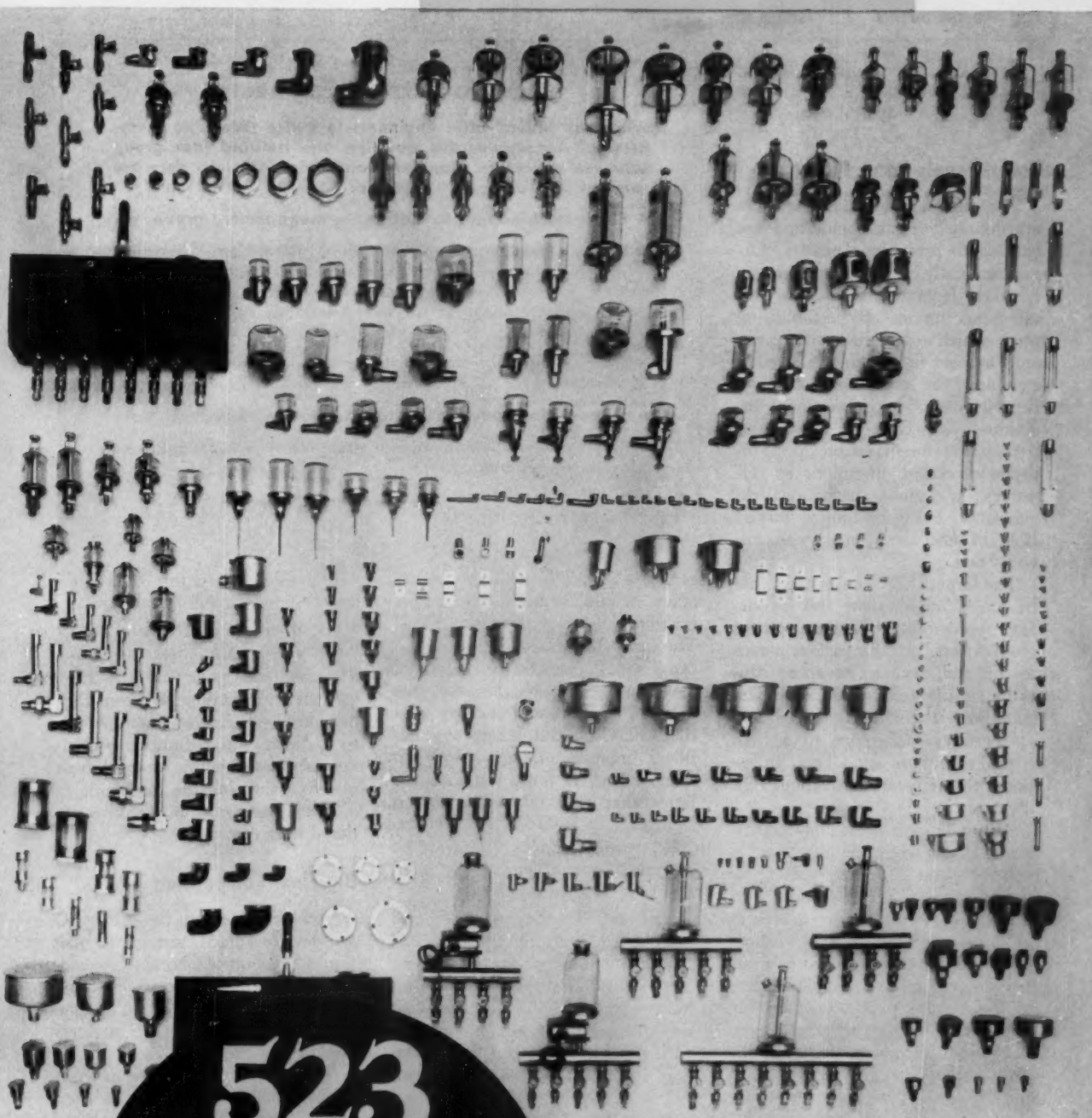
Blue-Collar Viewpoint

The stand taken by AFTE is that engineers are workers. No longer, says this union, can the average young engineer expect to become a "general practitioner"; rather, his job today requires that he focus all his attention on one narrow specialty. He has become highly dependent on his employer and on the other engineering specialists that make up his employer's staff. AFTE officials put it this way:

• *Engineers, architects, chemists, bacteriologists and all technicians are, in fact, subject to the same economic conditions as any other employees, regardless of the degrees of skill they may have. There is our real status, whatever words we may use. Today's engineer is an employee.*

—R. M. Stephens, president, AFTE

• *In elevating engineers to the elite status of doctors and lawyers, the Defence Production Act is applying an obsolete and superficial criterion. In modern industrial management the engineer is more closely akin to the machinist at his lathe and the production worker on the line. Engineers*



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and employers of engineers know this to be true.

—M. F. LUNCH, AFTE

Professionals Don't Picket

The ESA argues that engineers are definitely professionals and are entitled to professional status. Organizationally, ESA is an extremely loose federation of highly autonomous unions. By establishing units which solve their own problems and set their own membership standards, the federation tries to reflect its desire for professional individuality. Because it has placed tremendous emphasis on local independence and on unions as voluntary associations, the national organization has very limited power: Role of ESA is primarily an advisory one.

The largest ESA union states that its aim is "to stimulate and encourage the professional development of engineers." It lists various means to this end, such as advanced education, professional licensing under state laws, attendance at professional meetings, adherence to a high ethical standard, etc. This professional theme recurs throughout ESA literature.

Antiunion sentiment among engineers stems from the question of compatibility of unions and professionalism. Nonprofessional aspects of unionism seem to center around use of the strike weapon: Can professionals who attract attention while on the picket line go before the public another day and ask to be recognized as members of a learned profession? The ESA recognizes this problem; its member unions have gone on strike very rarely, and strikes have lasted for only short times. The ESA does not believe a union of professional people should resort to force to obtain its desires.

Plans for Expansion

Groups generally considered to be professional unions include several independent organizations (e.g., PTWU, LIEA, AEEA, REPEA), the Engineers and Scientists of America, and the Engineers and Scientists Guild.

The independents usually show no desire to become national organizations. While willing to assist others in establishing a union, they exist only to satisfy their own needs. The independents are important because they provide a potential means of expansion for the two national professional unions and the AFL-CIO. But before any national organization can absorb an independent, it must convince the latter that national representation is needed; it must also be able to fill this need. In the future, the independents will probably remain relatively insignificant.

The two federations, ESA and ESG, are dedicated to the unionization of engineers on a national basis. They believe that the engineer must have a collective-bargaining agent and that he should not be organized with production workers. They contend that existing trade unions cannot do an adequate job.

Of the two federations, ESA is by far the larger, stronger, older, and more experienced. Nevertheless, ESG, with 70 per cent of the ESA membership, is quite active. In response to a recent survey, one ESG-member union stated its current goals are:

- Organize all remaining West Coast divisions and subsidiaries of an aircraft manufacturer that is already partially organized.
- Reorganize divisions that have slipped away (become decertified).
- Organize a second (specific) aircraft empire.
- Organize the entire electronics industry in Southern California.
- Eventually federate all unions of engineers and scientists.

The ambitious policy of most ESG sections is, according to Leon Turner, president, Engineers and Architects Association, "continual expansion of existing units, establishment of new units, and the combining of all such units into an effective national organization."

Big-Time Competition

Competition from the AFL-CIO is not considered serious by the professional unions because, according to Joseph Amann, president, ESA, that organization must be completely revised before the engineer could fit in.

The trade unions have recently shown increased interest in engineers. The UAW has established the Aircraft and Avionics Council to give special consideration to bargaining needs of the technical employee; the IUE also has a technical council.

The Industrial Union Dept. (IUD) of AFL-CIO has also increased activity in assisting unions to organize the engineer. These increased efforts stem from the desire to maintain union strength in a changing population. Increases in membership cannot come from production ranks alone; white-collar employees now outnumber their blue-collar counterparts, and the ra-

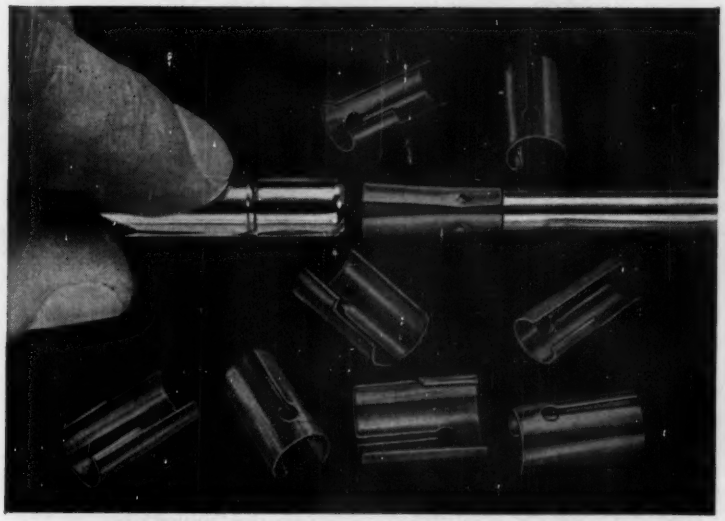
How to Attract Engineers

What can unions offer engineers to entice them into membership? To answer this question, the Harvard task group surveyed educators, managers, and union officials. Here are some of the suggestions received:

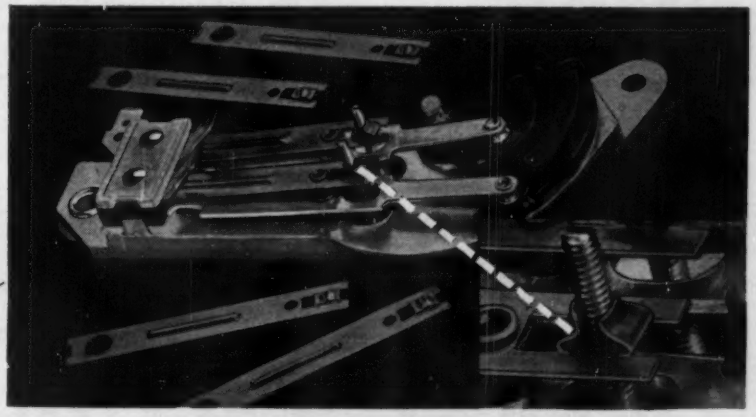
- **Eliminate bias and favoritism. — *management group***
- **Insure competent representation, protection of rights, leadership, professional recognition, better salary administration, improved working conditions, public relations, and equal opportunities for advancement.**
  —*professional-engineering union*
- **Raise recognition and prestige of the engineer in the eyes of his employer. — *professor at an eastern university***
- **Appeal to professional idealism.—*electronics company***
- **Improve communication between management and employees. — *federal agency***

CREATIVE COST CUTTING

Selecting the metal to fit the job can give you surprising savings in total cost



Small spring clips between telescoping parts of auto radio antennas must maintain electrical contact, hold parts firmly, give smooth sliding action. Brach Manufacturing Division of General Bronze Corp., Newark, N. J., found that spring clips of Duraflex®, Anaconda superfine-grain phosphor bronze, gave best positive electrical contact and improved smooth action in Brach Auto Antennas over original clips made of premium metals. The clips stand up in constant use, spot welding and fabrication are easier—and costs are about 25% lower.



In this G-E Automatic Coffee Maker control, a thermostat turns cam actuating switches—for high heat to brew coffee, for low heat to keep it warm. At first, upper switch element was an assembly of blade, bushing, and locking nut. Tinnerman Products Inc., Cleveland, Ohio, engineered a one-piece Speed Clip to replace it—by forming one thread in the blade and two prongs to lock the screw (see inset above). This simplification called for a superior phosphor bronze. Tinnerman found it in Duraflex, Anaconda superfine-grain phosphor bronze. It has higher tensile strength and endurance limit for long-lasting dependability—greater formability for economical manufacture. The result: unit costs were cut— and G-E assembles controls faster, more easily. 6045L

Quality control and cost reduction can go hand in hand. The secret is often simply matching the metal to the job. And Anaconda specialists, starting with 93 standard alloys, can offer an almost unlimited number of combinations of useful properties. For creative help in meeting your problems, write Anaconda American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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tio is growing at a high rate.

The IUD Committee on Problems of Professional and Technical Workers has developed a program of action:

- Sponsor an educational institution to train recruiters on white-collar job problems.
- Analyze contracts covering white-collar workers to determine if there is any uniformity.
- Set up state and national legislative programs that all unions can support.
- Publish material on how professional and technical employees have benefited from collective bargaining without detriment to their professional status.

The program has had only limited effect, mainly because IUD presently assists rather than directs efforts. Initiative must be taken by the international unions affiliated with AFL-CIO. The problem of which affiliates should unionize engineers may become quite significant and, according to Russell M. Stephens, president, AFTE, "could hurt AFL-CIO chances in this field."

Drawing the Battle Lines

If the AFL-CIO alters its appeals and objectives, it could offer serious competition to ESA and ESG. Should a struggle develop, however, the labor unions appear to be in an unfavorable position. In the past, most engineers faced with a choice have picked the professional unions, feeling these units are better able to represent them. In addition, ESA and ESG are not as hampered by the traditional stigma engineers attach to unions. Another important factor is the difficulties that would be inherent in the AFL-CIO:

- Internal conflicts as to which member unions should organize the engineers.
- Legal restrictions to mixed units (those that represent both professional and nonprofessional employees).
- Engineers' aversion to mixed units.

Recognizing these problems, AFL-CIO knows drastic action would be necessary to assure success. But growth pressures are tempting AFL-CIO to change its character.

One proposal being considered is the formation of a separate department specifically for the engineers. If this were done, the AFL-CIO, with its great financial strength and experience, might provide substantial competition for ESA and ESG.

If the AFL-CIO does revise its organization, the professional unions would give serious consideration to joining, Joseph Amann and Charles Hall (interim president, ESG) agree. The affiliation might be accomplished by establishing a separate engineering international with strong emphasis on professionalism.

T-H and the P.E.

Legislation could also have important effects. The present legal definition of a "professional" may be more precisely stated in the future. Currently, the work performed by an individual is the important factor in establishing professionalism, but many union leaders believe this definition is too loose. A more accurate one might be based on academic training and professional registration, as well as on work done. Should such a distinction be made, many members of the engineering workforce might find themselves without the rights provided by the Taft-Hartley law. Some might be absorbed in production-worker unions.

One of the current disagreements among unions is eligibility requirements for the "professional" unions. Degree held, type of work done, state registration, and the Taft-Hartley definition all have their advocates. In the ESA, the T-H definition is the basic measuring stick. The advantage cited by ESA officials is that the National Labor Relations Board uses this definition in determining the appropriate bargaining unit when organizational attempts are made by unions.

The ESA and other strictly professional unions are happy with the T-H definition. According to Joseph Amann, "including nonprofessionals in the same unit with professional engineers makes it more difficult to organize the (true) professionals." However, many engineering-union leaders consider ESG a better organization than ESA because ESA cannot provide leadership as long as it insists on remaining purely professional.

Beginning of the End?

By a decisive margin (3970 to 2603) Western Electric engineers last May voted down representation by the Council of Western Electric Professional Employees—National (member, ESA). The defeat is important because the issues involved were as hotly contested as those in the late presidential campaign. These quotes from before the certification election hint at how much was involved:

"Should the ESA win, it would be a significant victory . . . Western Electric, one of the largest employers of engineers in the country, has been desperately fighting unionization."

—JOSEPH AMANN, *president*
Engineers and Scientists of America

"If the ESA does not win the Western Electric election, more than 25 per cent of its current members and its only nationally certified union would be lost."

—CLARENCE T. SHOCK, *president*
National Society of Professional Engineers

Next article in this series, appearing in the December 8, 1960 issue of MACHINE DESIGN, will deal with what managers and professional societies have to say about unionism and what they plan to do to counteract its threat.

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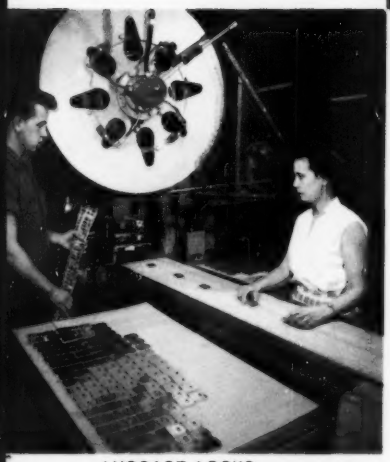
ACCORDION DOORS

HOME MAILBOXES



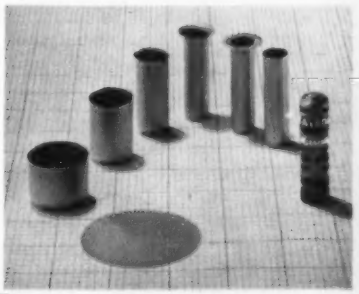
LUGGAGE LOCKS

LIPSTICK BASES

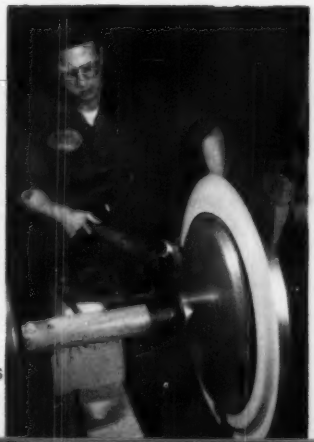
CABINET HARDWARE

HOW TO CUT COSTS, BOOST PRODUCT APPEAL WITH THOMAS STRIP PRE-COATED STEEL

please turn page



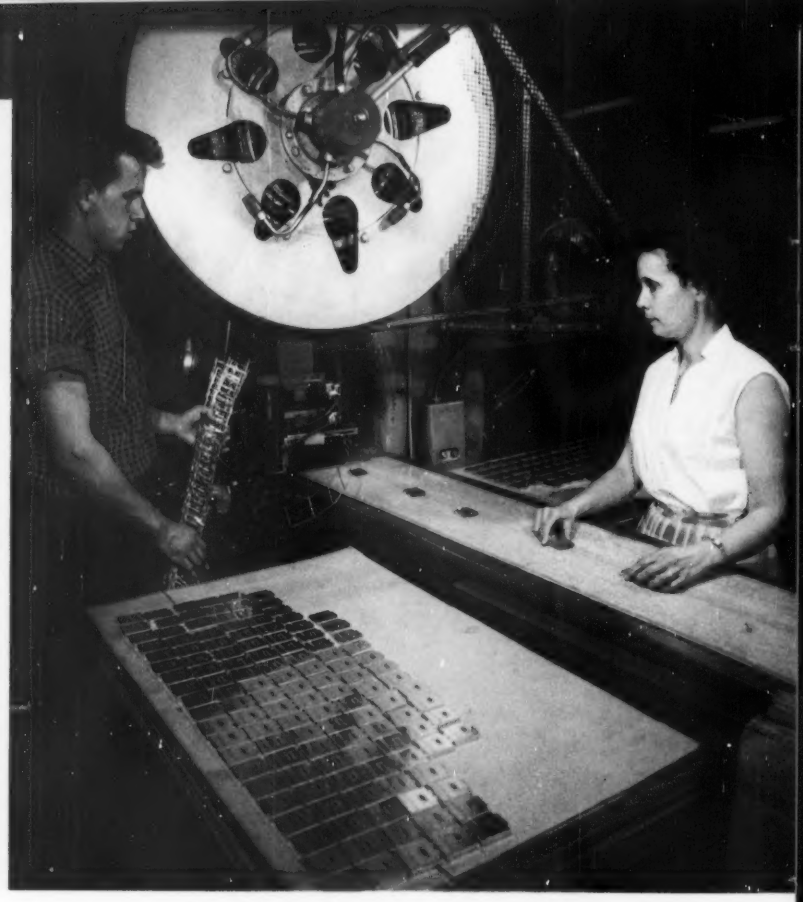
BATTERY CANS



BOILER TOPS

Pittsburgh Steel Company

Pittsburgh Steel Company



Luggage Locks—Brass Coated strip "strongly helped us compete against low-cost, brass plated imports." That's acclaim John A. Long, vice president-general manager, Long Manufacturing Co. Inc., gives Thomas Strip's brass coated steel. Long, of Petersburg, Va., is the nation's second largest luggage hardware maker. It was hard hit by foreign-made brass locks. "It was a crucial time in one of our big markets," says Sales Manager Edward C. Coleman. "We started looking for new methods and materials. Now, with new designs and using Thomas brass coated strip, we're able to fight foreign competitors." Eliminating plating and hand polishing with brass coated strip, buffed and lacquered on one side, Long trimmed 11 production steps. Result: 50% cost saving on compact-type luggage lock. Thomas Strip maintains product quality, helps Long increase die life; clear lacquer coat acts as lubricant in forming, prevents galling, and preserves product finish in inventory and in handling.

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Metal fabricators get a head start toward material and production savings with Thomas Strip's coated steel specialties.

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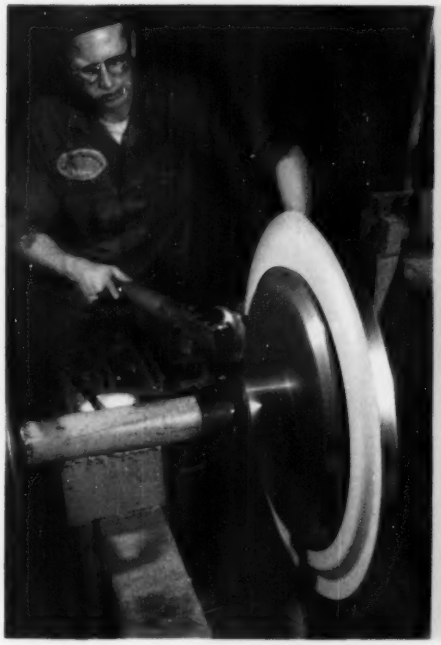
- **Shortens Manufacturing Cycle**—Precoated Thomas Strip is ready to fabricate when it's delivered. Initial preparation, cleaning, buffing, final finishing are already done in many cases—you're steps ahead in production.
- **Provides Economy of Steel**—By replacing more expensive metals, but retaining their finish or functional properties, precoated Thomas Strip reduces material costs.
- **Fabricates Easily**—Electrolytically applied, hot-dipped, painted or bonded, Thomas Strip coatings endure fabrication as readily as easy-to-work base steel.
- **Cuts Plating Costs**—Serving as final finish or as base for further plating or painting, Thomas Strip eliminates or at least reduces fabricators' piece-plating expense.
- **More Pieces Per Pound**—Precision rolling and plating to extremely close tolerances give maximum yield in parts per pound.

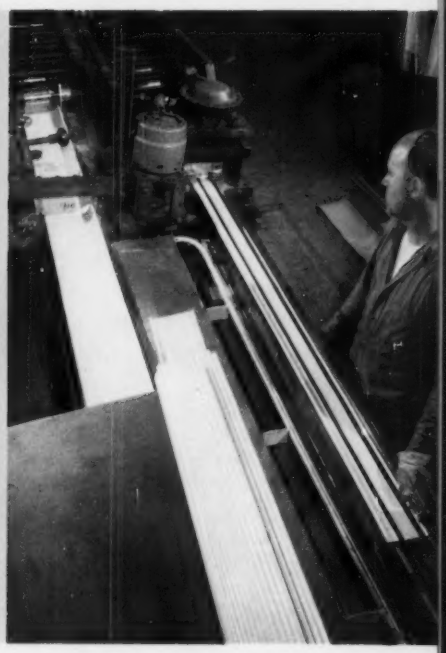
A study of the experiences of Thomas Strip users pictured on these pages should convince you of the benefits available to your product application—or to that product idea in the back of your mind. Read them.

If you need more convincing, detailed literature and samples are yours for the asking.

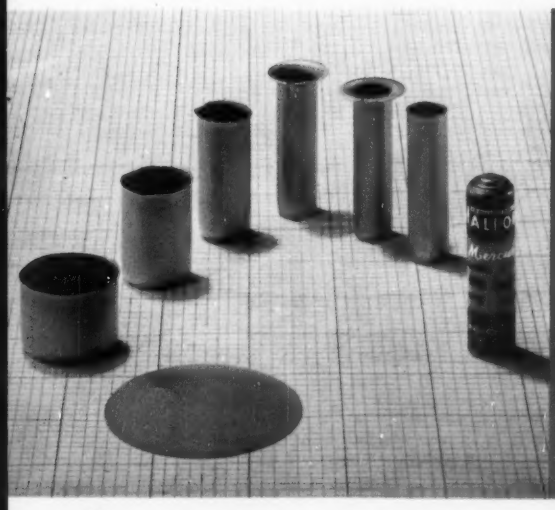
Better yet, contact one of the Thomas Strip District Sales Offices on the last page and ask for engineering or design help. And tell them you'd like to see our new slide film, "Bright, Modern Metals Provide Proof of the Pudding."

Accordion Doors—Plastic Coated Thomas Strip replaced hand laminating for "lead rail" of STEELITE plastic folding doors made by Clopay Corporation, Cincinnati, Ohio. Strip is roll formed with six 90° bends, ribbed and punched for rivets and door handle. Plastic endures stretching and compression. Also maintains "perfect lamination" to pass 100% inspection, says Purchasing Agent Lewis H. Washburn. Formed rails (left foreground) are assembled on rivet bench.





Boiler Tops—Lacquered Strip is spun formed by Edwards Engineering Corp., Pompton Plains, N. J., for boiler tops and top collars in packaged heating systems. Lacquer coat on Thomas Strip's aluminum-killed, drawing quality steel adheres without chipping or peeling. Edwards also uses lacquered strip to roll form back plates and front shields for baseboard units. Purchasing Agent John Bush says: "Thomas is more flexible and cooperative in giving us a quality product. We cut six steps, gained 1,500 sq. ft. of work space and eliminated fire hazards when we switched to prepainted strip. But most important, we can custom cut baseboard units to extra long lengths from prepainted coils." Edwards buys .029″ strip lacquered white on one side in 10.500″ and 5.625″ widths; 23″ width, beige lacquered on two sides.



Battery Cans—Nickel Coated Thomas Strip is used by Cly-Del Manufacturing Co., Waterbury, Conn., to produce mercury battery cases for P. R. Mallory Co. Example: RM-502 inner can, drawn by an Eyelet process from 2¼″ by .010″ strip. AK, non-scalloping steel with .000125″ nickel coat both sides must produce can 1.776″ by .506″ O.D. without draw rings, burrs, earing, peeling or flaking. Thomas has supplied nickel coated strip to Cly-Del nearly 20 years. "Precoated strip does this job better than if we plate after forming," says Purchasing Agent Raymond W. Drufva. "There's not much competition for Thomas in nickel coated strip for close tolerance work. It's the only producer able to supply the material we need for these battery cans."

Lipstick Bases—Copper Coated strip means a ⅔ material cost saving for Truelove & Maclean, Inc., Waterbury, Conn., Eyelet stampings specialists. Normally a brass part, a single style of this drawn shell, is produced at rate of 5 million yearly. Firm buys AK, non-scalloping, close gage (±.0005″) copper coated Thomas Strip for ductility, die lubricating and finish plating properties. Co-owners Tom Truelove and Don Maclean say: "We wouldn't attempt some of these jobs unless the material was copper coated steel. Generally it's no harder to work steel than brass when the steel is Thomas Strip's copper coated. There's not much competition for Thomas in this line." (Top photo shows copper coated lipstick bases being packaged with magnetic lifter.)

PATTERN ROLLED STEEL OFFERS UNLIMITED DESIGN OPPORTUNITIES

Home Mailboxes—Pattern Design. The Lady was looking for product appeal. She found it in pattern design sheet from Pittsburgh Steel Co. The Lady is Miss Jeanette L. Troy, director of purchases for The Randall Co. of Cincinnati, Ohio. She explains: "We were trying to find something new for our colonial style home mailboxes—a decorative effect that was different. Pittsburgh Steel's Pattern Design No. 101 gave us the appeal boost we were looking for—and without a proportionate cost boost."

Randall, a division of Textron Inc., produces the boxes for another Textron division, Wagner Manufacturing Co. of Sidney, Ohio. Industrial Engineer Wade Hartman says pattern design sheet saves 50 cents over a mailbox made of similar patterned materials. Rolled-in leather design shows no distortion in forming; permits full thickness of steel to be used in blanking, forming machines. Randall buys pattern sheets in commercial quality .024″ thick and in widths 39⅝″, 40¼″, 42⅛″.

Cabinet Hardware—Pattern Design—Thomas Strip's antique patterned steel helps Ajax Hardware Corporation of Los Angeles build strength and beauty into Early American cabinet hardware. President Norman D. Louis says: "Thomas Strip saves many hours by eliminating production steps. The uniformity of appearance, quality and workability of Thomas Strip's patterned steel makes it possible to match Ajax Early American cabinet hardware year after year. Production is fast because of Thomas Strip's close tolerances and formability." Ajax Hardware gives Thomas Strip's uncoated strip an electrolytic coating of rich antique copper or dull black. Photo shows packaging operation.

THOMAS STRIP DIVISION

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			Philadelphia	Warren, Ohio

All materials distort in time, and the platinum-iridium bar that became the world's standard of length in 1889 is no exception. The loss in accuracy of the bar which undoubtedly has occurred, and the need for constant recalibration of standard copies throughout the world, have long been cause for considerable concern among scientists. The unpredictability of physical material, as compared with the immutable constancy of the length of light waves has recently resulted in a

New Standard of Length

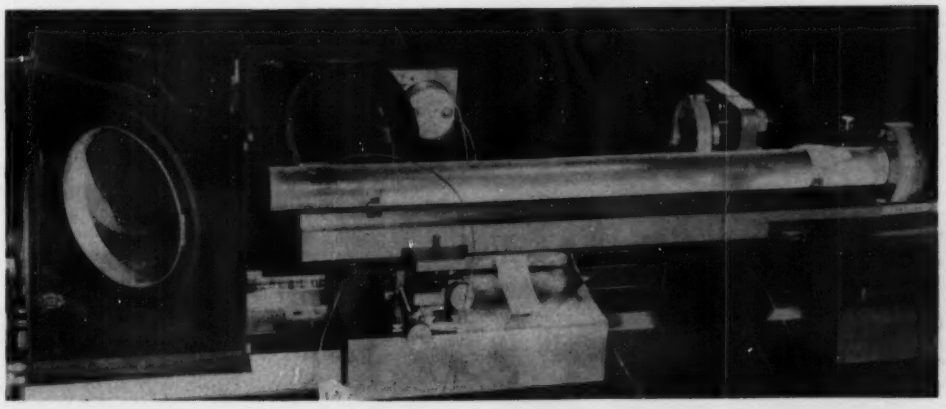
PARIS, FRANCE—The meter recently adopted by the world as a new international standard has widened the United States by 75 centimeters.

The platinum-iridium meter bar, the world's standard of measurement for over 70 years, has been superseded by the wavelength of orange-red light from a krypton-86 lamp. Under an agreement reached by the 11th General Conference on Weights and Measures, the meter has been defined as 1,650,763.73 wavelengths.

The new definition relates the meter to a natural constant which is believed to be immutable and can be reproduced with great accuracy in any well-equipped laboratory. In the past, duplicates of the engraved international meter had to be returned to Paris for recalibration. Discrepancies were sometimes noted, and the standard bar itself was considered unstable by some scientists.

No material change in the world's measurement of length is caused by the adoption of the new standard, but it is possible to measure some dimensions more accurately than was previously possible. Careful experiments performed at the U. S. National Bureau of Standards and at Canada's National Research Council are in substantial agreement; both show that the distance between Washington and New York is about 3 in. further when measured in terms of the new standard of length.

The meter brings the standard length used by spectroscopists for the past 50 years into agreement with that of other branches of science.



Interferometer is used to compare the old standard (a quartz copy of the platinum - iridium bar) with the new standard. The ends of the bar are optically detected by mirrors that have been optically wrung to the bar ends.

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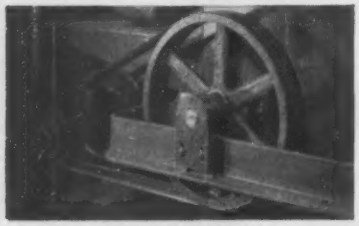
WOOD'S POWER TRANSMISSION PRODUCT NEWS



NEW, NON-FREEZING VARIABLE

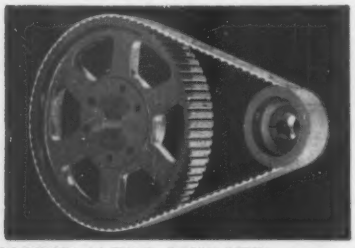
Wood's new "SVS" stationary control, variable speed drive has positive locking collars and other, patented features which eliminate freezing, assure easy speed change. No lubrication is required. Uses standard v-belts and stock companion sheaves. Write for Bulletin 6102.

Circle 419 on Page 19

NEW, TREMENDOUS SAVINGS

Wood's new Ultra-V Drives handle up to 3 times more horsepower than conventional v-belt drives in a given space . . . reduce overall drive dimensions as much as 50% . . . cut weight up to 25% and costs up to 30%. Write for Bulletin 9102.

Circle 420 on Page 19



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Wood's Timing Belt Drives provide positive, slip-free action. Belts are all muscle. No high initial tension, tension devices or lubrication needed. Drives are light weight, compact . . . quiet and clean. Wide load and speed range. Equipped with famous Sure-Grip Bushings. Write for Bulletin 2100.

Circle 421 on Page 19

MP/360B

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Meetings and Shows

Nov. 30-Dec. 2—

Futuronics Exposition, sponsored by the Long Island Electronics Manufacturers Council, to be held at Roosevelt Raceway Exhibit Hall, Westbury, Long Island, New York. Further information can be obtained from Rogers & Agate Inc., 19 W. 44th St., New York 36, N. Y.

Dec. 3-6—

Fourth Annual International Visual Communications Congress to be held at the Hotel Sherman, Chicago. Sponsors are the American Institute for Design and Drafting and the Society of Reproduction Engineers. Additional information is available from VCC headquarters, 10600 Puritan Ave., Detroit 38, Mich.

Dec. 4-7—

American Society of Agricultural Engineers. Winter Meeting to be held at the Peabody and Chisca Hotels, Memphis, Tenn. Further information is available from ASAE headquarters, St. Joseph, Mich.

Dec. 5-8—

American Rocket Society. Annual Meeting and Astronautical Exposition to be held at the Shoreham Hotel, Washington, D. C. Further information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

Dec. 5-8—

National Conference on the Application of Electrical Insulation to be held at the Conrad Hilton Hotel, Chicago. Sponsors are the American Institute of Electrical Engineers and the National Electrical Manufacturers Association. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Dec. 12-15—

Atomic Industrial Forum and American Nuclear Society. Atomic industry exhibitions and conferences to be held at the California Masonic Memorial Temple, San Francisco. Further information can be obtained from AIF, 3 E. 54th St., New York 22, N. Y.

Dec. 13-15—

Eastern Joint Computer Conference to be held at the Hotel New Yorker and Manhattan Center, New York. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers, and Association for Computing Machinery. Additional information is available from IRE, 1 E. 79th St., New York 21, N. Y.

Dec. 17—

Institute of the Aerospace Sciences. Wright Brothers Lecture to be given at the Natural History Bldg. Auditorium Smithsonian Institution, Washington, D. C. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 9-13—

Society of Automotive Engineers Inc. International Congress and Exposition of Automotive Engineering to be held at Cobo Hall, Detroit. Additional information is available from the society, 485 Lexington Ave., New York 17, N. Y.

Jan. 17-19—

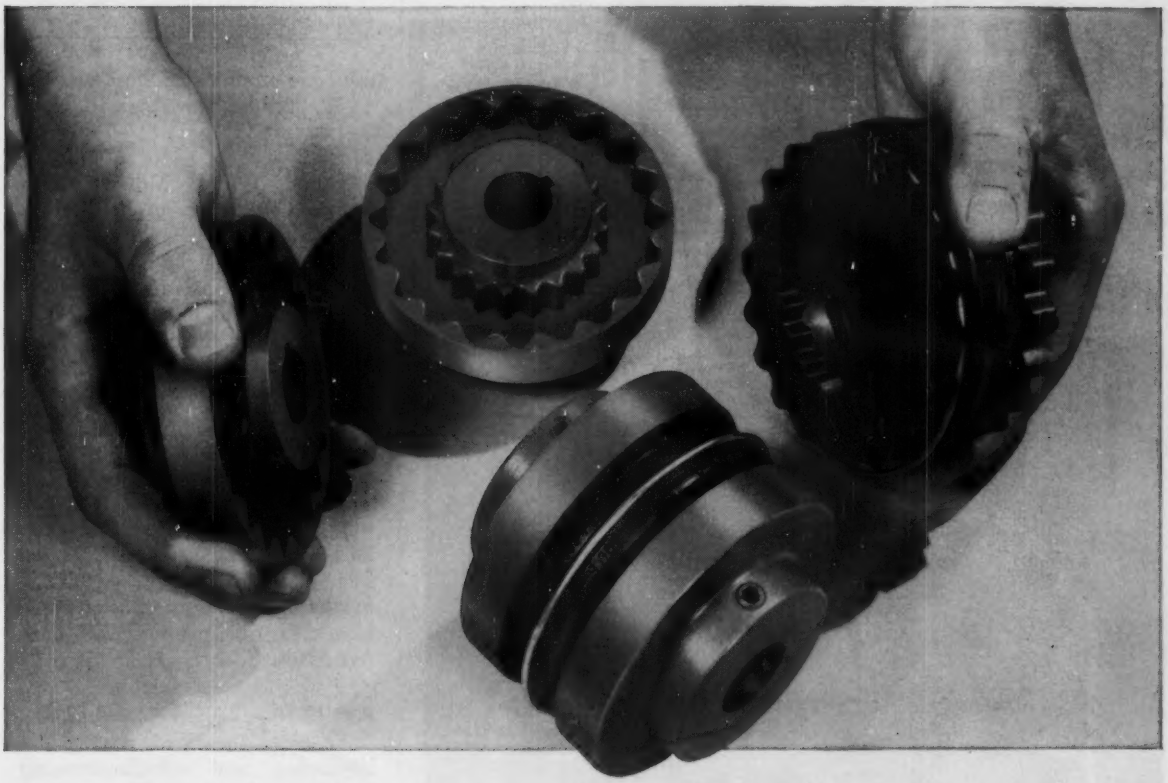
Instrument Society of America. Winter Instrument - Automation Conference and Exhibit to be held at the Sheraton-Jefferson Hotel and Kiel Auditorium, St. Louis. Further information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Jan. 23-25—

Institute of the Aerospace Sciences. Annual Meeting to be held at the Hotel Astor, New York. Honors Night Dinner is Jan. 24. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 29-Feb. 3—

American Institute of Electrical Engineers. Winter General Meeting to be held at the Hotel Statler, New York. Further information is



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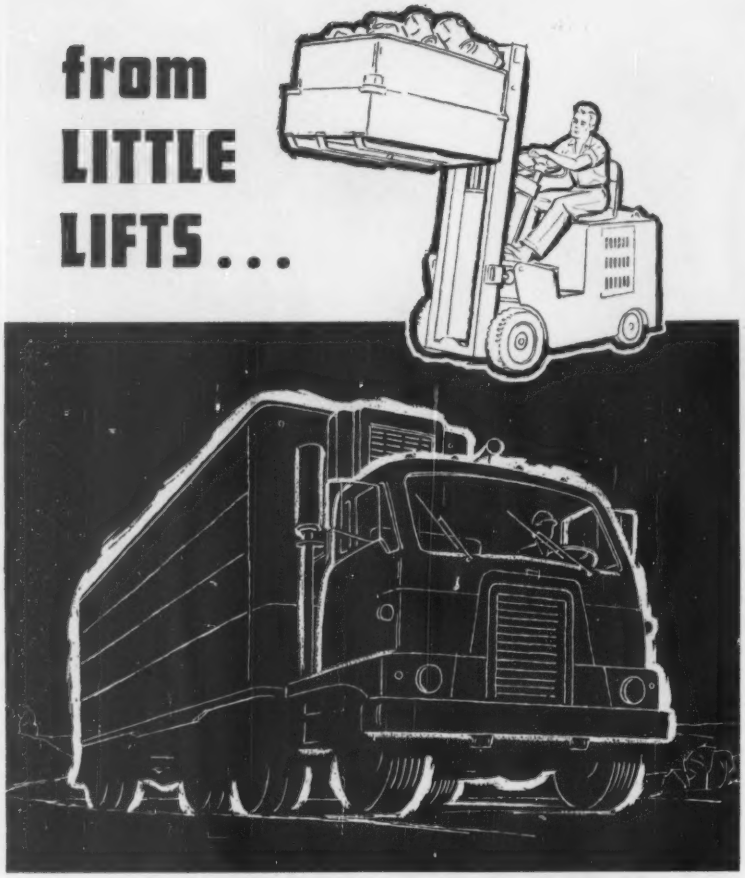

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Feb. 1-3—

Second Winter Military Electronics Convention to be held at the Biltmore Hotel, Los Angeles. Sponsors are the National Professional Group on Military Electronics and the Institute of Radio Engineers, Los Angeles section. Additional information is available from IRE, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Feb. 7-9—

Society of the Plastics Industry Inc. Sixteenth Reinforced Plastics Div. Conference to be held at the Edgewater Beach Hotel, Chicago. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 13-16—

American Society of Heating, Refrigerating and Air-Conditioning Engineers. National Meeting and 15th International Heating & Air-Conditioning Exposition to be held at the International Amphitheatre, Chicago. Additional information can be obtained from exposition headquarters, 480 Lexington Ave., New York 17, N. Y.

March 8-10—

Instrument Society of America. Annual Conference on Instrumentation for the Iron and Steel Industry to be held at the Roosevelt Hotel, Pittsburgh. Further information can be obtained from Richard R. Webster, Jones & Laughlin Steel Corp., Research Laboratory, 900 Agnew Ave., Pittsburgh 30, Pa.

Short Courses and Symposia

Dec. 7—

Seminar on Electrohydraulic Servo Systems, sponsored by the Milwaukee School of Engineering and the Milwaukee Chapter of the Fluid Power Society, to be held at the school. Information is available from Mel Streigel, Milwaukee School of Engineering, Technology Park, Milwaukee 1, Wis.

Dec. 8-9—

Engineering Institute on Optimizing Research Performance to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institute, University of Wisconsin, 4020 Stadium, Madison, Wis.

Jan. 9-11—

Seventh National Symposium on Reliability and Quality Control to be held at the Bellevue-Stratford Hotel, Philadelphia. Sponsors are the Institute of Radio Engineers, American Institute of Electrical Engineers, American Society for Quality Control, and Electronic Industries Association. Additional information can be obtained from James H. Goodman, Radio Corp. of

Jan. 23-Feb. 2—

Engineering and Management Course to be held at UCLA. Participants select four classes from a group of 22, including such subjects as reliability for modern industry, industrial psychology, engineering and research administration, and effective managerial communication. Public speaking classes are also offered. Further information can be obtained from Reno R. Cole, Co-ordinator, The Engineering and Management Course, College of Engineering, University of California, Los Angeles 24, Calif.

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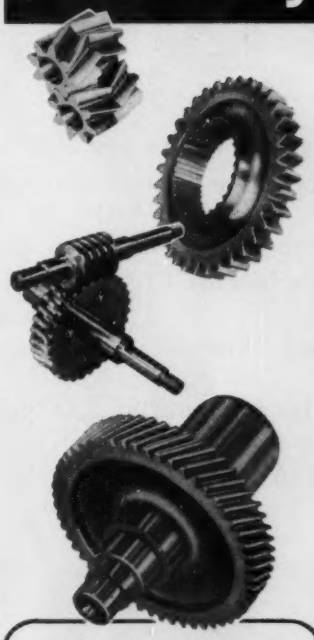

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9237 HUDSON BOULEVARD NORTH BERGEN, N. J.

Circle 424 on Page 19

Improved reliability • Greater capacity • No increase in price

NEW DIRECTIONAL VALVE DESIGNS WITH VICKERS Q-E-L* SOLENOIDS

- New Q-E-L* solenoids assure quiet, cool operation plus shock-free performance through superior cushioning.
- Four to five times more cycle life than previously obtainable with ordinary air-cooled solenoids.
- Capacity increased from 50 to 500% on new designs.
- All models suitable for pressures to 3000 psi.
- Complete range of sizes available for maximum flows to 440 gpm.

MODEL DG5S4 solenoid-controlled, pilot-operated valve is rated at 30 gpm (with nominal pressure drop) with a maximum capacity of 80 gpm without malfunction, depending on circuit conditions and valve type. Standard subplates are available with ¾-in. and 1 in. pipe thread connections. SAE straight thread port connections can also be provided. Write for Catalog 5001-C.

MODEL DG4S4 is rated at 8 gpm (with nominal pressure drop) with a maximum allowable capacity of 12 gpm without malfunction. Maximum recommended operating pressure is 3000 psi. Standard subplates are available with ⅜ in. or ½ in. pipe thread ports. SAE straight thread port connections can also be provided.

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* Q-E-L designates Quiet Extended Life solenoid—a *Vickers exclusive.*

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walter dorwin teague:
no gee-gaws on the 707

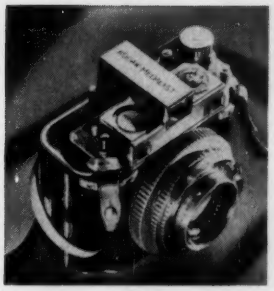
teague talks design

In 1942 a man named Walter Dorwin Teague published "You Can't Ignore Murder," a mystery novel. It is probably the only attempt at bafflement in his long history, because Walter Teague has been making products speak clearly for themselves since the Twenties.

Teague has rightly been called the dean of industrial design. He began as an artist in 1908 designing advertising, books and magazine illustrations. If you're old enough to remember Locomobile and Pierce Arrow ads, Teague designed them. In 1927, Eastman Kodak asked him to redesign their cameras. He made a proposal to spend one week a month in their plant observing production problems and techniques, and *then* redesign the cameras. That simple principle of knowing how a product is made, of understanding all the complexities of the production line, is still a Teague trademark. And Eastman Kodak is still a Teague client.

In the thirty-plus years since that camera assignment, Teague has explored just about every nook and corner of the wonderful world of three dimensions. He designed the classic Marmon 16 automobile in 1930, with his son as collaborator; he was on the Design Board of the 1939 World's Fair. When World War II exploded, the Navy asked Teague to perform design work on their 16-inch guns in order to eliminate possibilities of explosions caused by loading malfunctions. Today he still works for the Bureau of Ordnance. He has 120 people in his organization, a branch in San Juan and task forces scattered across the United States

Teague has designed service stations, railway equipment, plane interiors, heating appliances, business machines and machine tools, offices and furniture, showrooms and department stores, even periodicals. One of the most impressive things he has done is the Boeing 707 jet interiors. Mr. Teague recalls: "Boeing was concerned about their ability to sell the 707 because they hadn't made civilian planes for years. We convinced them to build a full-size mockup of the interior. They gave us *carte blanche* with body engineers to collaborate, and they refused to look at it until it was finished. We made it complete to the tiniest detail. It cost half a million



dollars and helped in selling most of the huge fleet now in the air. Our staff is responsible for the final interiors of the planes purchased by eighteen or more airlines, and for the interiors of executive planes purchased by the United States Government."

Whether mammoth jet airliners or chairs, a product is designed to five principles that are the *modus operandi* of the Teague organization. "First of all, the redesigned product has to work better for our efforts," Teague says. "It should be more convenient to use, more humanized. It must make honest use of the material it's made of, and it's got to be capable of being efficiently manufactured at the proper price. We assiduously avoid gee-gaws or extraneous ornamentation that adds nothing but price to the product. Finally, the design must give the user an emotional pleasure or gratification each time it is used." Selection of the right material for the job is important to each of Teague's requirements. "We endorse no material over another," Teague says. "We first look for the material that is best in keeping with the product's desired personality. Strength and durability are highly important in material selection. Then we make sure our client's tooling can handle the material we have in mind. Above all, it takes the right material to sell the product to the consumer."

Teague has used practically all materials known to man and it is no accident that a great many of his designs use steel in one way or another. "The wonderful thing about steel is its versatility," says Teague. "Its many alloys, old and new, give it adaptability that other materials don't have. Its strength, both in tension and compression, qualifies it for literally thousands of uses. And stainless steel is another reason why steel is a modern metal because it gives so many designs their contemporary look."

The moral is this: steel is an ageless metal, as much at home in the Boeing 707 and today's elegant tableware as it was in medieval days. Its enduring modernity will always be recognized and used by designers like Walter Dorwin Teague.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

USS TRADEMARK United States Steel

designing with stainless steel

The ideal design has been described as one in which the properties of the material are fully utilized in the finished product. This ideal is difficult to achieve, and no group of materials comes as close to permitting this ideal as stainless steel.

To put it differently, no other material combines so many outstanding properties as the stainless steels. Stainless steels have high tensile strength. All are hardened and made even stronger by cold working. As a family they offer superb resistance to the corrosive effects of an enormous variety of reagents. They have unusual resistance to high temperature oxidation, and are distinguished by relatively low heat conductivity. And on top of their remarkable physical properties, stainless steel's lustrous appearance and sales appeal scarely need mention.

There are over 30 types of stainless steel today.

The history of stainless steel's use is marked by designers who turned a healthy profit with a quality material but mainly with sound ideas. They're the men who used stainless for its strength and sales appeal in toaster covers, its appearance and machinability in wrist watches, its structural properties and cleanability for truck trailer parts. Stainless steel cuts weight and adds years to the life of architectural panels; its corrosion resistance and smooth, pocket-free surface have made it the standard of the dairy industry. There are literally thousands of applications of stainless steel in which designers have utilized one, two or more of the remarkable properties of stainless steel.

By reflecting the color of its surroundings, stainless steel contributes to harmonious design.

Types 302, 410 and 430 make up 75% of stainless steel's uses.

Good design is honest design, whether it uses stainless steel or other materials. Yet the fact remains that there is no other commercial material quite as versatile as stainless steel. The applications shown on these pages are just a few of the hundreds of uses to which stainless is put every day. To learn more about stainless steel and its design properties, call our nearest sales office or write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

Successful designers don't substitute stainless steel sections for sections of other materials. They design to stainless' unique properties.

Good design doesn't stop with function and sales appeal. It must also be capable of economical manufacture. As a comprehensive guide, send for the free book described at the right.

Stainless steels represent but a few of the thousands of grades of steel in existence today. United States Steel makes a complete line of stainless steels as well as alloy, high strength and carbon steels. Bring your design problems to us.

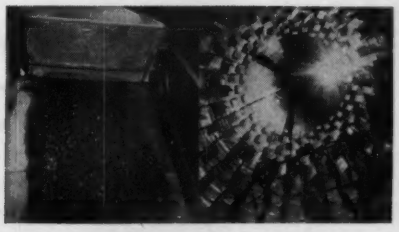
USS is a registered trademark

USS **United States Steel**

No Material comes close to stainless steel's versatility. By way of illustration, here are a few "opposites" that prove our point.

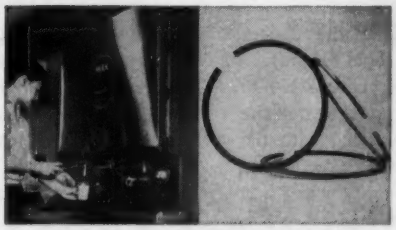
HOT. Temperatures in a jet afterburner reach 1400°F.

COLD. Stainless heat exchanger operates at temperatures as low as —443°F.



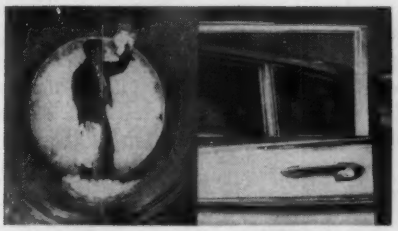
WET. Combination of moisture and coal would corrode nearly anything but stainless.

DRY. Rotary dryer is used to dry pharmaceutical ingredients.



CLEAN. Milk dispensers of stainless steel prevent contamination.

DIRTY. Stainless piston rings resist high temperature corrosion.

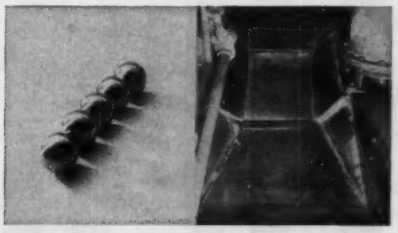


INSIDE. Chemical tanker needs simple wash-out for cleaning.

OUTSIDE. Stainless automobile trim stays bright and good-looking.

LIGHT. Stainless steel jewelry has a light, graceful appearance.

HEAVY. Strength and hardness of stainless combine to make safe doors safe.

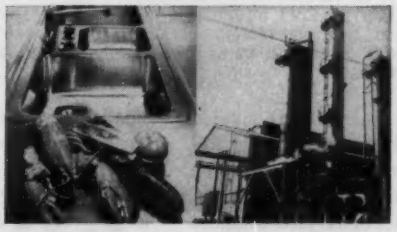


ROLL. Stainless ball bearings take a lot of punishment.

SLIDE. Abrasion resistance of stainless steel makes chutes last longer.

FORM. Stainless steel wrist watch keeps time and beauty.

FUNCTION. Stainless steel muffler defies heat with silence.



WATER. Stainless sinks stay bright and beautiful.

FIRE. Stainless steel shingles inside cat crackers are red hot.

This mark tells you a product is made of modern, dependable Steel.

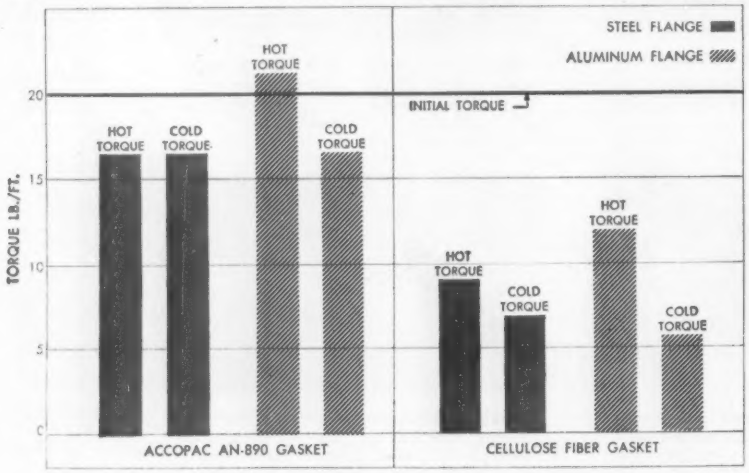
Gasket engineering

TORQUE RETENTION WITH FIBER GASKETS

A comparison of torque retention characteristics of cellulose fiber and asbestos fiber gaskets under conditions of cyclic heating and cooling . . . with both steel and aluminum flanges.

E. M. SMOLEY
Research Physicist
Armstrong Research and Development Center

Where gasketed joints are exposed to cyclic heating and cooling, serious loss of initial bolt torque usually results. And the loss is generally more severe when the flange is made of aluminum.



Results of hot and cold torque tests on steel and aluminum flanges. Flanges were torqued to 20 ft-lbs and heated to 300° F. for 18 hours. Hot torque was measured at 300° F. Cold torque was measured after cooling to room temperature. These test assemblies were cycled between room temperature (73° F.) and 300° F. several times over a two-week period, with no significant variation in results.

This problem was recently studied by engineers at the Armstrong Research and Development Center. The test work compared the torque retention characteristics of a typical cellulose fiber material and a beater-saturated asbestos material — Accopac AN-890.

Tests were run using both steel and aluminum flanges. In each test, bolts were torqued to 20 pound-feet at room temperature. The gasketed assemblies then were exposed to 300° F. for 18 hours. Torque was then rechecked while the flanges were still hot (hot torque) and again after the flanges had cooled to 73° F. (cold torque).

In the first tests, Accopac AN-890 was used. The results are shown at the left of the chart. Note that with the steel flange, there was a relatively small loss of torque — and no difference between the hot and cold torque readings.

With the aluminum flange, the hot torque reading actually exceeds by 1 pound-foot the original bolt loading, while the cold torque reading shows a loss of 3 pound-feet.

This differential of 4 pound-feet is the result of the expansion of the aluminum. With aluminum flanges, the torque, or load on the bolts, increases as the temperature rises. To maintain a seal, a gasket must translate the thermal expansion of the aluminum into bolt torque increases without undergoing any plastic flow.

The second group of tests used a typical cellulose fiber gasket, with results as plotted in the chart. Note that with this material there was a serious loss of bolt torque (as much as 72%) in both the steel and aluminum flanges.

The reason appears to be that cellulose fiber gaskets flow or extrude at high temperatures and are not able to "follow" the variations in flange loading brought about by aluminum expansion. These materials apparently do not have the capacity to retain a satisfactory percentage of initial torque where operating conditions are similar to test conditions described above.

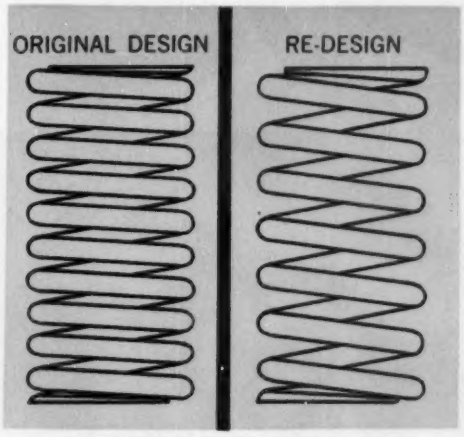
On the other hand, Accopac AN-890 resists crushing and extruding and is able to compensate substantially for the effects of aluminum flanges.

If you have a specific problem related to torque retention in gasketed joints, we will be glad to make suggestions. Just write to us, giving details of your application. If you do not have a copy of our Gasket Design Manual, write Armstrong Cork Company, Industrial Division, 7111 Dean Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS
1860-1960 Beginning our second century of progress

70 POUNDS OF SPRINGS

were just going along for the ride!



10 coils—.120″ wire
130 lbs. of wire per
1M springs

7 coils—.105″ wire
60 lbs. of wire per
1M springs

Because of mounting cost conditions, a user of motor-support springs asked for a complete design check. Redesigned by A.S.C. engineers, required stresses were met by a slight change in wire size, allowing a reduction in number of coils from 10 to 7. This meant a saving of 70 pounds of material per thousand springs. Because of the shorter length of wire, coiling and grinding speeds were increased, heat-treating time reduced. Saving to the customer—40%.

How about the springs you use? A consultation on your specifications costs you nothing. Just contact any Division of Associated Spring Corporation. For a handy reference to spring action, write for "Spring Design and Selection—in brief."

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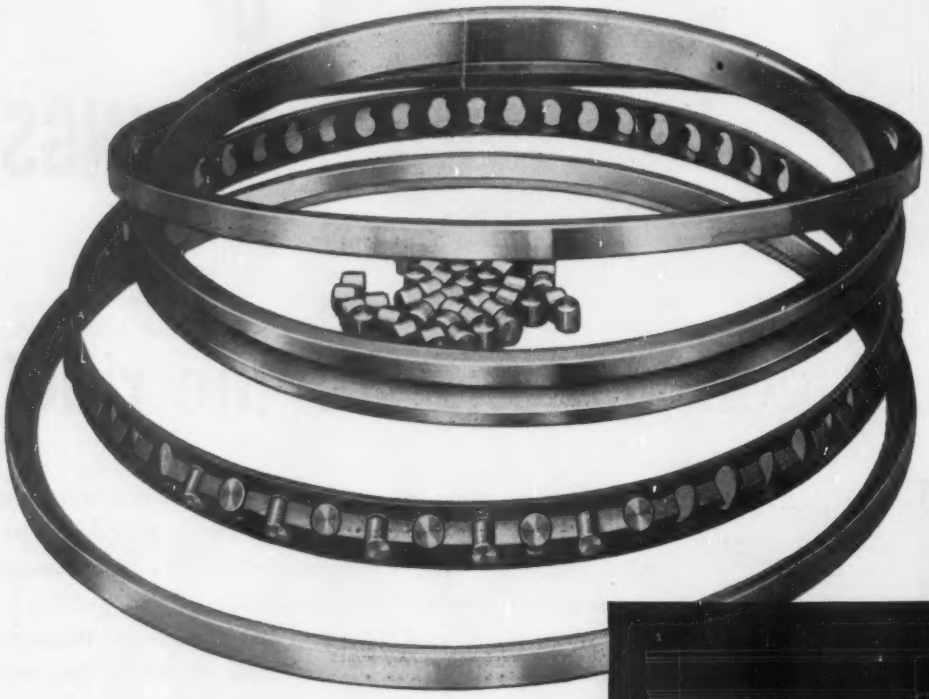
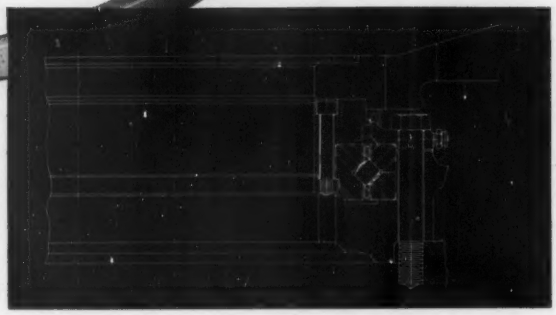
Years of Accurate Bearing Performance

With the MESSINGER "X" BEARING





ENDURING ACCURACY... revolving parts not deviating one thousandth of an inch after years of service... is one answer to the wide use of the patented "X" Bearing in a wide variety of applications ... from work rolls to gun turrets to radar screens.

VERSATILITY is another reason why the "X" Bearing offers so many practical design advantages. It can carry the load in three directions—thrust either way and radial. Actually, it can be designed to take the place of four bearings—two thrust and two radial.

TYPICAL APPLICATIONS...

Work, press, calender and suction rolls; boring mill tables; rock crushers; glass grinding machines; propellers; artillery and naval gun mounts; radar screens.

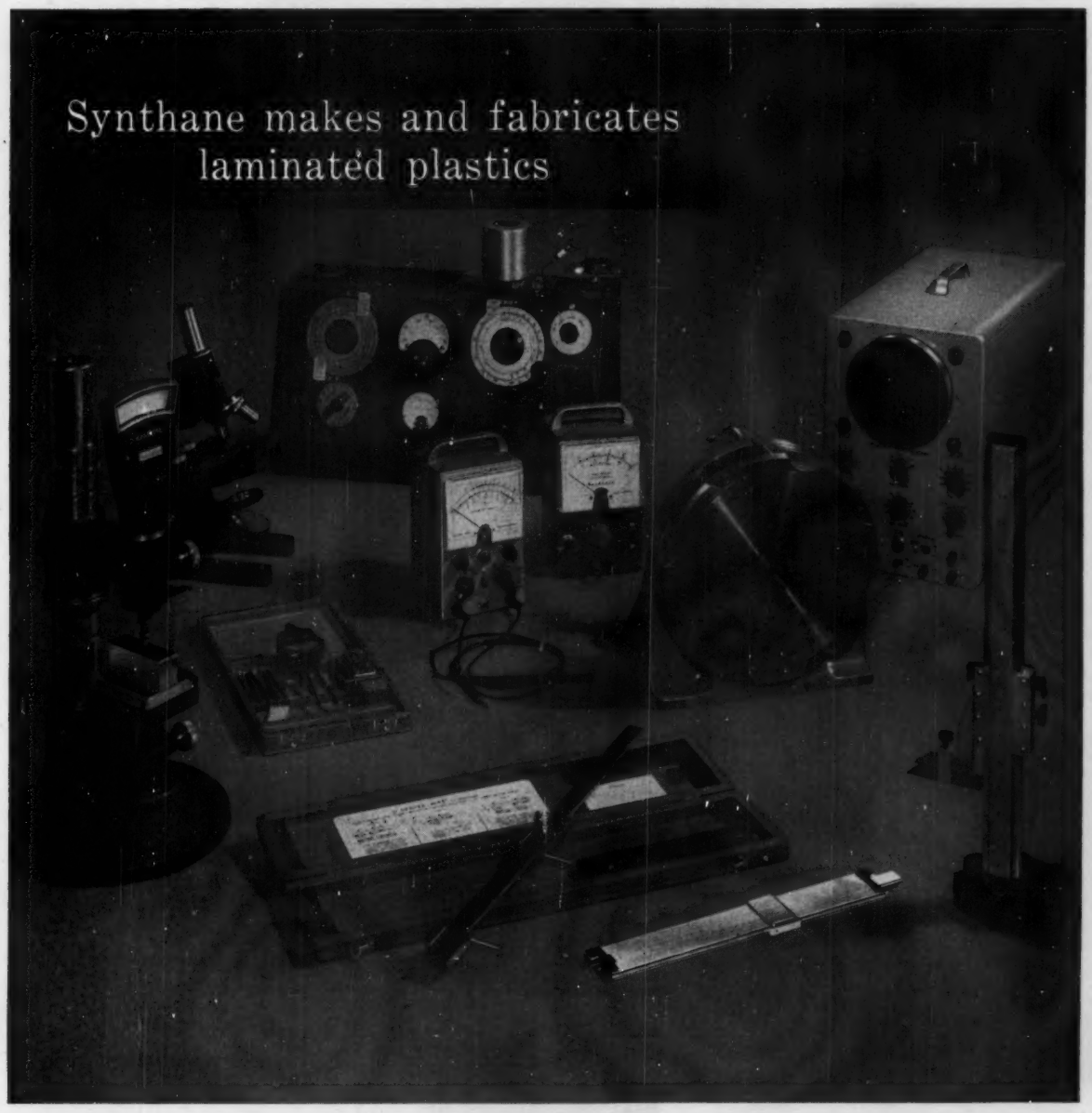
CONSIDER THE "X" BEARING on your next design problem. Standard sizes range upwards from 4.000" I.D., 6.250" O.D. and 1.125" in width. Write for complete information.

MESSINGER BEARINGS, Inc.

ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.

"Smoothing Industry's Pathway for Nearly Half a Century"



Quality is Precision and People and Pride

We make and sell laminated plastic sheets, rods, and tubes. But nearly all of our customers prefer us to fabricate their parts from these materials.

Synthane quality starts with the rigid inspection of incoming raw materials. From this point forward, to the finished laminate, control is the byword. In fabricated parts, too, quality is precision, people and pride. Measuring instruments of all kinds, many of our own design, gauges, precision tools and other specialized equipment all contribute to Synthane quality products. Our people, through years of experience, know how to machine laminated plastics to achieve the dimensions and tolerances you require.

Quality is a matter of pride on the part of every Synthane craftsman who works on your job. And sixty per cent of our people have been with us for 10 years or more.

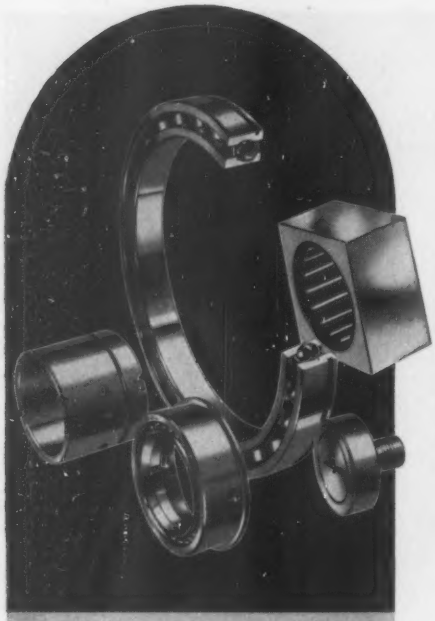
Aside from the first class job Synthane gives you, it will hardly pay you in money or headaches to do your own machining. Ask your Synthane representative for a quotation. You'll find him in the classified telephone book of any principal city or write Synthane Corp., 5 River Road, Oaks, Pa.

You furnish the print—we'll furnish the part

SYNTHANE CORPORATION OAKS, PENNA.

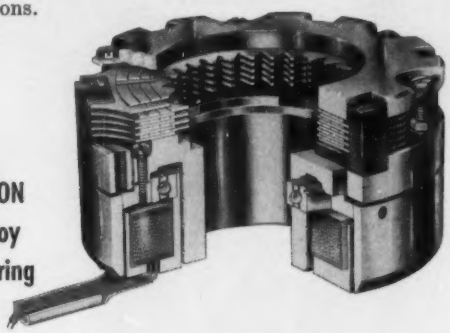
Sheets • Rods • Tubes • Fabricated Parts
Molded-laminated • Molded-macerated

Circle 428 on Page 19



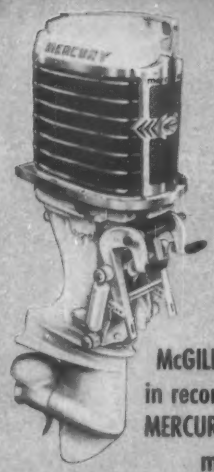
McGILL® can solve your special purpose bearing problems

You may have found that a special bearing is the only way to add anti-friction advantages to non-standard shaft and housing dimensional combinations—perhaps a special type bearing incorporating odd shaped components or adjacent machine members will do the job best. Such special bearing design and production is part of everyday activity with McGILL. So don't design around a bearing barrier until you have consulted McGILL creative engineering. They will welcome an opportunity to make recommendations.



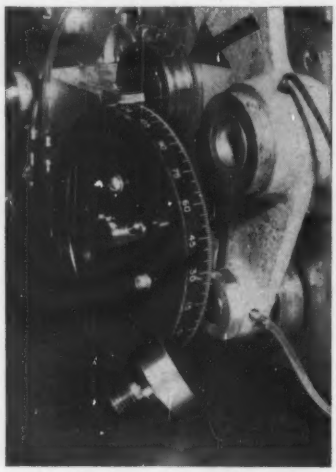
FAWICK AIRFLEX DIVISION magnetic clutches employ McGILL special ball bearing

A special McGILL precision ball bearing was developed to meet the exacting anti-friction requirements of the Fawick Stationary Field Magnetic Clutch. This extremely narrow and thin section bearing of comparatively large bore diameter is built to precision tolerances to accurately position and align all moving parts in relation to the stationary coil. Radial fit up is closely controlled to provide accuracy of magnetic flux air gaps. Retainer is nonmagnetic. Fawick relies on the McGILL bearing to facilitate the rapid and smooth response of the clutch even when operating at high cyclic rates.



McGILL bearings in record-breaking MERCURY outboard motors

Hydroplane speeds averaging over 107 miles per hour, runabout endurance runs of 50,000 miles in 68 days and outstanding power exhibitions by Mercury outboard motors are a true test of component performance. McGILL split center main bearing sleeves are used in 60-80 horsepower six cylinder Mercury outboard motors and have played an important part in the high standards of performance set by these motors.



CAMROL® bearings protect reliability of IBM accounting machines

McGILL CF Series CAMROL bearings improve performance and provide an additional safety factor for greater reliability in IBM 407 Accounting Machines. The CAMROL bearings are located on the card feed cam follower arms and they operate a pressure plate on the sensing unit of this high speed card feed. The IBM 407 Accounting Machine combines outstanding arithmetic ability and printing at a speed of 150 lines per minute.

engineered electrical products

McGILL®

precision needle roller bearings

Send for free copy of McGill Bearing Catalog No. 52-A.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

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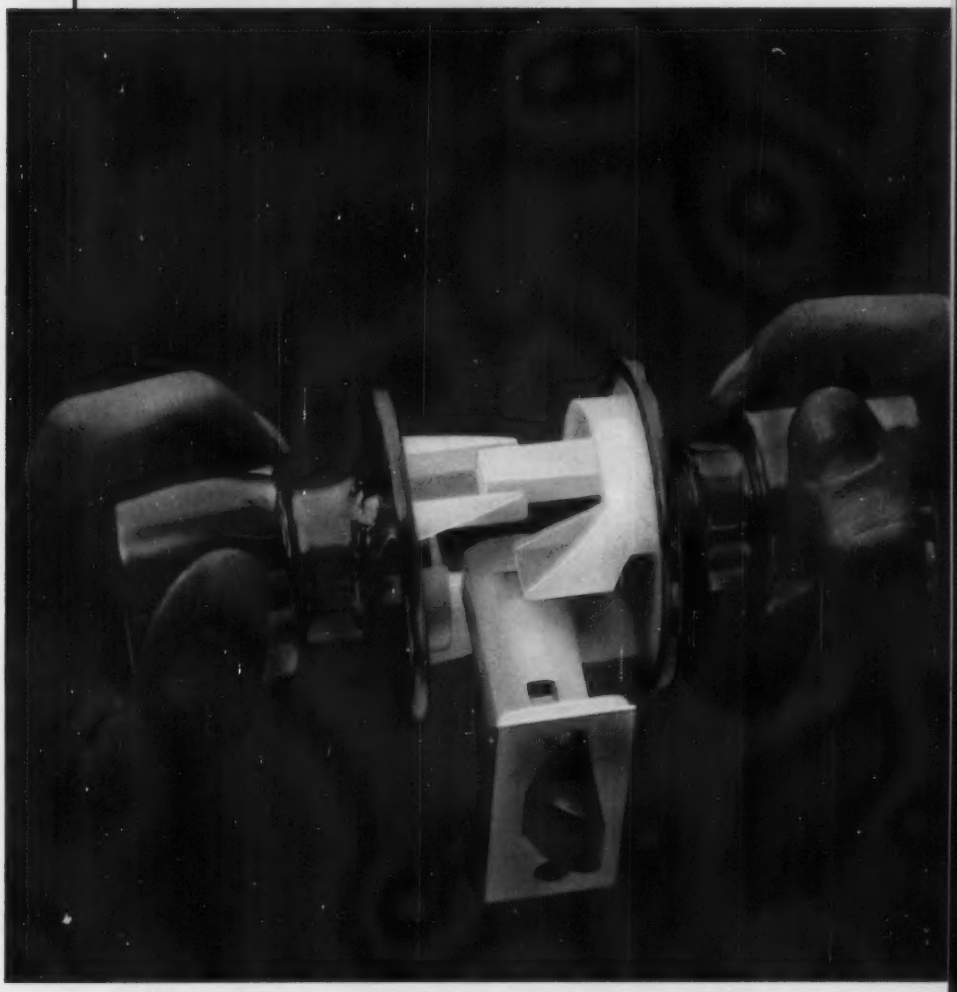
Circle 575 on Page 19→

working with

Du Pont Zytel®

NYLON RESINS

one of Du Pont's versatile engineering materials



New lockset designed with ZYTEL® offers easy installation...lifetime service...economical production

This is the first plastic lockset ever commercially available—and it took a material with remarkable properties to make it: a material that is exceptionally tough and abrasion-resistant; a material with friction so low as to make lubrication unnecessary; a material that is rust- and corrosion-proof; a material that can be economically molded to close tolerances in large quantities, and one that requires little or no finishing.

In short, it took Du Pont ZYTEL nylon resin.

In this radical design innovation, almost all working parts except the knobs are molded of tough Du Pont ZYTEL. Installation of the lockset is made foolproof; round and square sleeves mate with round and square posts. The entire set is held by two lead-through bolts that drive directly into tap holes in the chassis sleeves. And a self-aligning latch case lets the installer swivel the latch to the right or left of the central lock assembly to compensate for bevel-edged doors or for improper boring. In action, the bolts of ZYTEL were tested up to 1,500,000 cycles—equivalent to more than 100 years of normal household use—before showing any perceptible wear. And the lockset functions smoothly and quietly without lubrication. The Lockwood Hardware Manufacturing Company of Fitchburg, Mass., reports that the parts of ZYTEL are economically mass-produced, need virtually no finishing operations.

On the following page, you will find further illustrations of the design improvements and cost reductions made possible by the complete line of ZYTEL nylon resins.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

working with

Du Pont Zytel®

nylon resins

one of Du Pont's versatile engineering materials

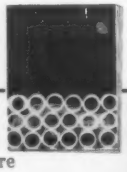
This "anti-gurgle" device is used by a major automobile manufacturer in cooling systems with hot-water heaters, to eliminate air bubbles and noisy heaters. Molded of a special ZYTEL nylon resin specifically designed for hot-water service, it costs only 25% of previously used copper part. (Molded by Kuhlman Plastics, Kansas City, Mo.)

Complex end-turn insulator molded of ZYTEL is used to simplify assembly and improve performance of fractional-horsepower motors. ZYTEL provides the necessary molding characteristics, good electrical properties, heat resistance and high strength in thin sections. (Molded by Carpart Plastics, Inc., for Redmond Co., Inc., both of Owosso, Mich.)

Feeding-finger pads for screw-machine stock are economically molded of tough, abrasion-resistant and resilient ZYTEL. According to the manufacturer, they are the best pads yet developed for feeding soft materials . . . and for centerless stock, where freedom from marking is important. (By T and M Engineering, Inc., of Valparaiso, Indiana, for Brown & Sharpe Mfg. Co. of Providence, R. I.)

Doing it better at lower cost: 3 more examples of ZYTEL® in action

The versatility of ZYTEL nylon resins stems directly from an unusual union of mechanical, chemical, electrical and processing properties. Some combination of these properties may well provide a solution to a design problem of yours. Find out more about the performance and cost advantages made possible by ZYTEL—simply fill out and mail the coupon below.



E. I. du Pont de Nemours & Co. (Inc.), Dept. C-1 2 3
Room 2507Z, Nemours Building, Wilmington 98, Delaware
I am interested in evaluating ZYTEL for the following use:

_____

*Name*_____

*Company*_____ *Position*_____

*Street*_____

*City*_____ *Zone*_____ *State*_____

In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

POLYCHEMICALS DEPARTMENT

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . *THROUGH CHEMISTRY*

ZYTEL® *nylon resins*

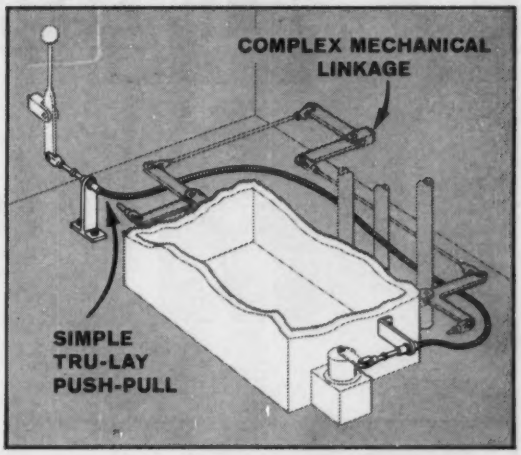
one of Du Pont's versatile engineering materials

Alathon® · Delrin® · Lucite®

ACCURATE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

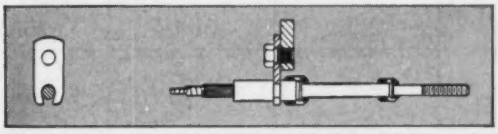
— — with Tru-Lay *PUSH*-PULL Controls

If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over short or long distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, vibration rattles and lost accuracy.

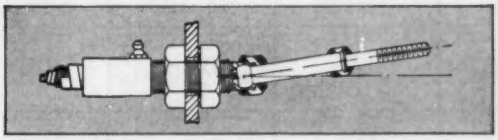


THESE FEATURES HELP SOLVE DESIGN PROBLEMS

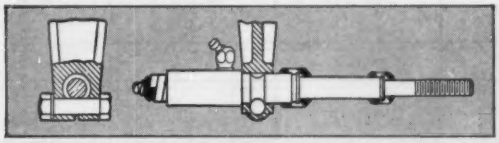
Anchorages



Clip anchorage • a simple clip for light loads

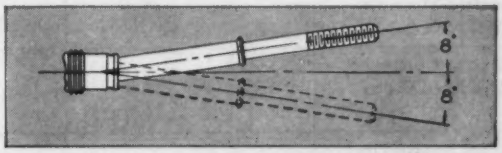


Bulkhead anchorage • for heavy-duty installations



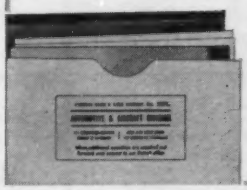
Machined bracket anchorage • can be furnished for mounting any PUSH-PULL cable at the swivel terminal

Swivel Action



Standard assemblies have end fittings with a swivel movement of ± 8° to compensate for misalignment and rise or fall of lever arms. Swivel joints, and the sliding ends, are sealed against dirt and moisture.

PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN



• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

ACCO

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

6800-A East Acco Street, Los Angeles 22 • 929-A Connecticut Ave., Bridgeport 2, Conn.

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From Monsanto FluiDesign Service...

DIELECTRIC FLUIDS FOR NEW ELECTRICAL AND ELECTRONIC USES

Monsanto can supply you with a series of dielectric liquids that offer the optimum combination of properties for liquid cooling and insulation. Many of the fluids described below are now used commercially in capacitors, transformers, "miniaturized" electronic packages, cables, amplifiers, solenoids, thermostats, computers, and circuit breakers.

Examples:

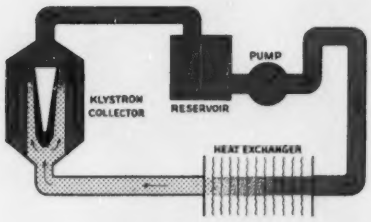
A. In electrical equipment such as transformers, Monsanto's askarel-type fluids offer a series of *fire-resistant* dielectrics. These fluids make a firesafe liquid-fill insulation for equipment that then may be located in operating areas without special precaution or costly shielding.

B. As impregnants for premium-quality capacitors, high dielectric Monsanto fluids permit a substantial decrease in capacitor size—about 50-60%—compared to oil-impregnated

Dielectric Fluids	OS-59	Coolanol® 35	Coolanol 45	Aroclor® 1221	Aroclor 1232	
Properties						
Dielectric Strength, 25°C, 60 cps, 0.1.	44KV	47KV	27KV	35KV	35KV	
Dielectric Constant, 25°C, 1000 cps	2.46 (10^6cps)	....	2.2 (10^6cps)	4.5	5.4	
Volume Resistivity, ohm-cm, 25°C	$6.7x10^{13}$	....	$9x10^{10}$	$>5x10^{12}$	$>5x10^{12}$	
Power Factor, % 1000 cps, 25°C	0.006 (10^6cps)	....	0.4 (10^6cps)	<0.1	<0.1	
Viscosity, CS −65°F	1380	934	2400	....	....	
100°F	6.8	6.5	12.2	4.6	6.9	
210°F	2.2	2.2	3.95	<1.8	<1.8	
Pour Point, °F	<−85	<−85	<−85	34	−32	
Boiling Point, °F 760 mm. Hg	>700	>600	>700	527	554	
Fire Point, °F Cleveland Open Cup . . .	435	430	430	349	460	
Thermal Conductivity Btu/hr/ft/ft²/°F	0.077	0.079	0.080	0.067	0.063	
Specific Gravity @25°/25°C	0.88	0.89	0.89	1.18	1.26	
Coefficient Thermal Expansion, per °F	0.00046	0.00047	0.00048	0.00039	0.00040	

capacitors. Because their dielectric constants are closer to those from the capacitor paper itself, they help achieve a more evenly distributed dielectric stress than is possible with mineral oil.

C. Monsanto's coolant-dielectrics dissipate heat and operate liquid-cooled power packs, magnetrons, traveling wave tubes, klystrons with precise temperature control. Liquid cooling with these dielectrics permits miniaturization of electronic components, conserves size and weight. These special synthetic fluids are



also lubricants, and the single fluid can double as the hydraulic-fluid activator for tuning mechanisms as well as the coolant for the electronic unit.

This schematic circuit (at left) shows how Coolanol 45 liquid cools a klystron. Pumped around the collector, Coolanol 45 absorbs surface heat from the tube wall and carries it away for dissipation in the heat exchanger.

Check the fluids shown for application in equipment you are using or developing. Monsanto can supply you with a dielectric fluid for virtually any electrical or electronic application, can be most helpful in guiding you in the early design stages of equipment that will require a liquid dielectric.

A sample of the fluids shown will be sent to you for evaluation on request. Please specify the particular fluid that interests you and state the nature of the application so that pertinent details can be sent you. For further information on available fluids, request a copy of FluiDesign Service's FLUID DATA FILE.

Simply write on your company letterhead.

Monsanto

Monsanto Chemical Company
Organic Chemicals Division
FluiDesign Service, Dept. 2768A
St. Louis 66, Missouri

	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260	Biphenyl	HB-40	Santowax® R
	35KV	35KV	35KV	35KV	35KV	35KV	35KV
	5.8	5.6	5.0	5.0	2.5	2.65	2.58
	$>5x10^{12}$	$>5x10^{12}$	$>5x10^{12}$	$>5x10^{12}$	$>1x10^{12}$	$>5x10^{13}$	$>1x10^{13}$
	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	.... 17.2 2.5	.... 45.3 3.2	.... 46.4 6.14	 75	.... 0.98	.... 29 3.9	....
	2	20	50	88	156	—13	293
	617	644	689	714	491	683	687
	>610	>640	>662	698	255	385	460
	0.058	0.057	0.054	0.051	0.076	0.072	0.063
	1.38	1.45	1.54	1.62	0.984	1.002	0.955
	0.00038	0.00039	0.00037	0.00037	0.00050	0.00041	0.00052

18 lbs. of stainless per ring eliminated by flash butt-welding extruded sections

Amweld experience in forming and flash butt-welding rings from extruded sections reduced the cost of $52.00 rings to $21.00 each. A special section closely approximating the cross-section of the finished part was selected to replace heavy rectangular bar stock. By leaving over 12,000 lbs. at the mill, the cost of these rings was reduced by 40%—not to mention large savings in machining time.

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and machining facilities, phone or write.

GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

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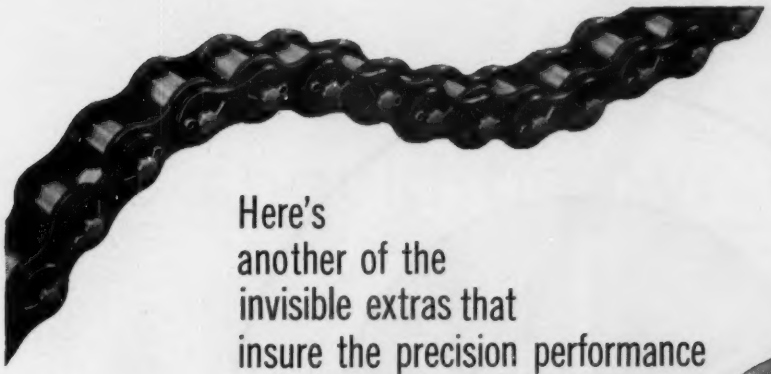


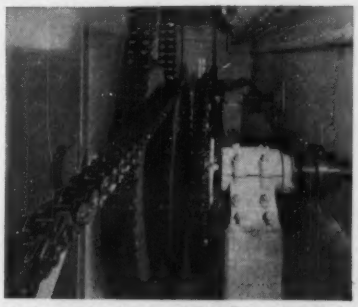
Here's
another of the
invisible extras that
insure the precision performance
of LINK-BELT roller chain

Painstaking precision of heat-treat control gives you

uniform strength in every link

To produce roller chain of utmost uniformity, Link-Belt maintains exacting control of all heat-treating processes. With equipment and instrumentation exactly tailored to the need, all processes are carefully adjusted to suit the characteristics of each heat and analysis of steel. Result: roller chain of uniform strength *well above accepted standards*. Chain that absorbs shock loads, delivers full power under continuous heavy going.

Precise heat-treat control is one of many *invisible extras* that contribute to the greater strength and endurance of Link-Belt roller chain. Others include prestressing, pitch-hole preparation, shot-peening. These features—plus painstaking precision and inspection in every step of manufacture—assure you of chain that can easily cope with today's heavy loads and high speeds.



Single and double strand Link-Belt roller chains combine to provide dependable, positive power transmission at this installation.

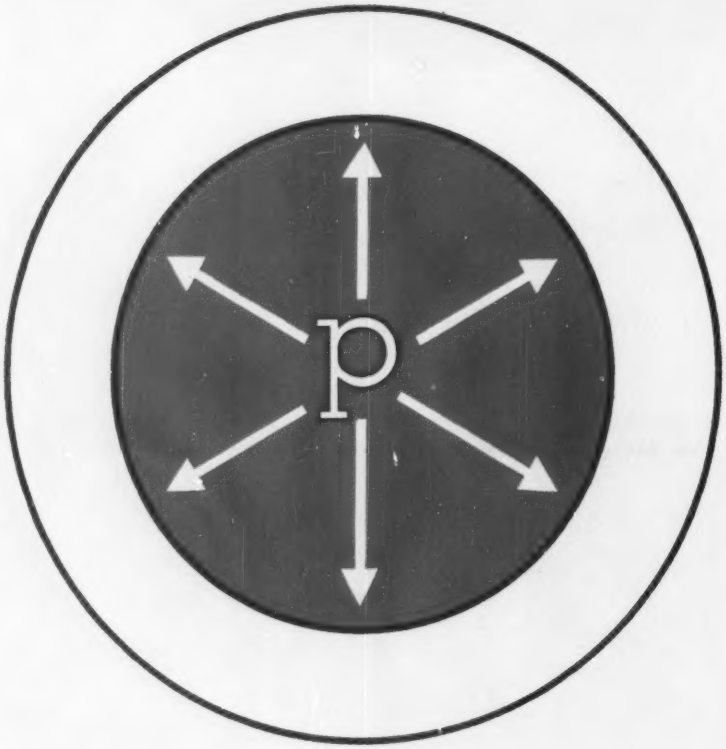
For engineering assistance in applying industry's preferred roller chain, contact your nearest Link-Belt office. See CHAINS in the yellow pages of your phone directory. Ask for Book 2657.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15.595

LINK-BELT

ROLLER CHAINS AND SPROCKETS

Circle 433 on Page 19



Metallurgical Phenomena... and the metals to cope with them.

These are the stock-in-trade of the Lukens Application Engineer—whether the problem be one of pressure (symbolized above) or corrosion or abrasive impact or structural stress or high and low temperature. Investigation of the best steels for "problem" applications has been carried on for years by the Lukens Application Research team. We would welcome the opportunity to contribute the results of this research to your own design knowledge. Please contact us in your early design stages. Call collect: John D. Heffernan, Manager of Application Engineering, Extension 422, Lukens Steel Company, Coatesville, Pennsylvania. Or write: E-110 Services Building.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

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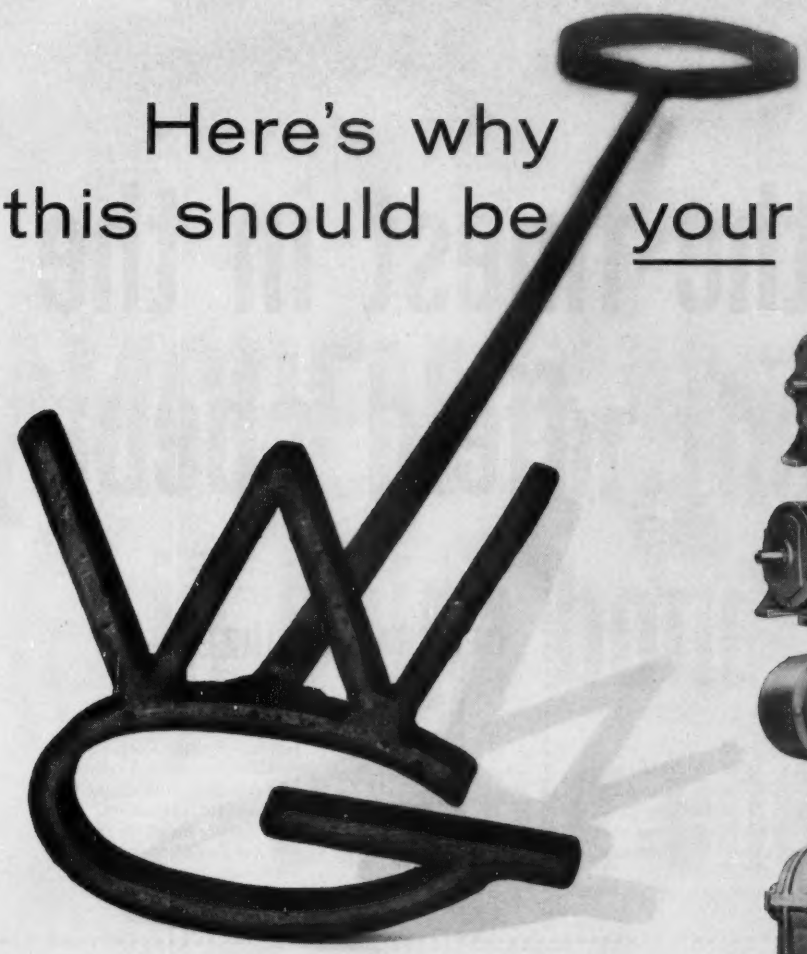
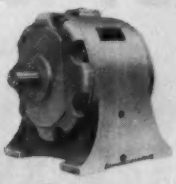
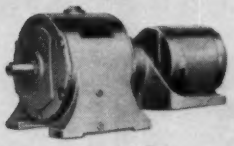
Circle 435 on Page 19→

Here's why this should be your brand

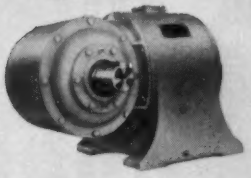




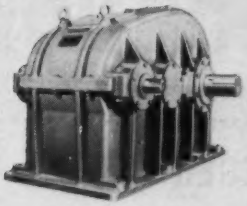
StraitLine
Speed Reducer



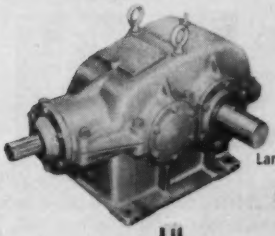
Shovel Base
Horizontal
Gearmotor



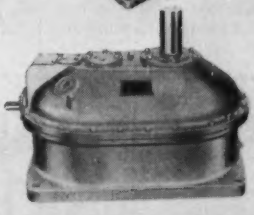
Right Angle
Speed Reducer



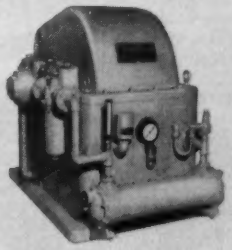
Parallel Shaft
Speed Reducer



Large Right Angle
Horizontal
Speed Reducer



Large Right Angle
Vertical
Speed Reducer



Small High
Speed Unit

because . . . on the long run . . .

QUALITY COSTS YOU LESS!

You can't always see quality . . . many times a second rate piece of machinery can look good. It's on the long run that quality shows up and actually saves you money.

Industry has proved **Western Gear** power transmission drives for 72 years. And Western Gear has cooperated with industry by consistently designing into its drives the features their customers want.

Take reliability, a critical requirement in any power transmission installation: precise gear cutting and finishing techniques and careful heat treatment to uniform hardnesses are unequalled in **Western Gear's** finished drives. This means long life, quiet operation, minimum maintenance and reliable full load performance for you year after year.

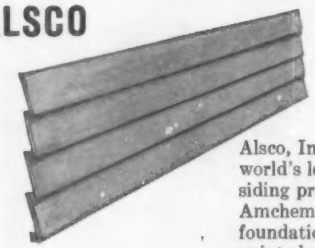
Next time you need gear drives for any power transmission application, check the brand that's designed and built to your needs and to your long run requirements . . . **Western Gear.**

For free catalogs, write to **WESTERN GEAR CORPORATION,** Industrial Products Division, P.O. Box 126, Belmont, California.

WG INDUSTRIAL PRODUCTS DIVISION

7 of the finest in the field specify

ALSCO

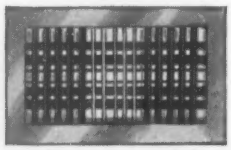


Alsco, Inc., one of the world's leading aluminum siding producers specifies Amchem Alodine® as the foundation for a successfully painted, durable aluminum surface.

GENERAL BRONZE

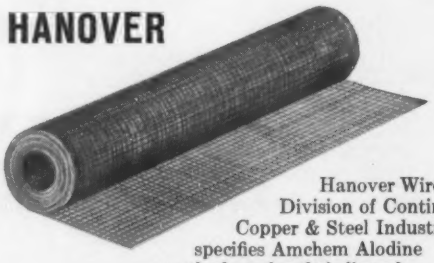
The Alwintite Division of General Bronze Corp. specifies Amchem Alodine and Amchem Aluminum Etchant for a superior, long lasting finish on their popular line of residential aluminum windows.

KRUEGER



Krueger Air Conditioning Corp. specifies Amchem Granodine® for superior pre-paint protection and paint adhesion on steel registers, grilles and diffusers for air conditioning and heating.

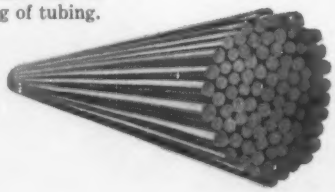
HANOVER



Hanover Wire Cloth Division of Continental Copper & Steel Industries specifies Amchem Alodine as the base for their line of non-glare, corrosion-resistant, color-fast aluminum screening.

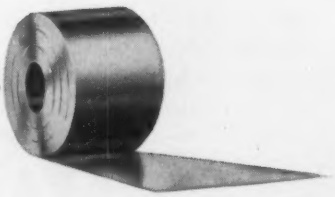
WALLINGFORD STEEL

Wallingford Steel Company, one of the world's largest producers of stainless steel tubing, specifies Amchem Granodraw SS® to facilitate forming of tubing.



CAROLINA METALS

One of the country's top painted aluminum strip processors, Carolina Metal Products Corp., specifies Amchem Alodine for continuous strip pre-paint treatment of aluminum.



AMCHEM for the finest in paint bonding and coating chemicals

BOEING AIRCRAFT

Internationally known Boeing Aircraft Co. specifies Amchem Alodine as a pre-paint treatment, and to treat unpainted portions of the famous 707 jetliner fuselages and engine pods.

If you're looking for superior corrosion resistance, paint bonding and coating performance . . . write for complete information on these and other Amchem chemicals for the metalworking industry.

AMCHEM

Amchem, Alodine, Granodine and Granodraw are registered trademarks of

AMCHEM PRODUCTS, INC.

(Formerly American Chemical Paint Co.)

AMBLER, PA.

Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.

Circle 436 on Page 19

Ucinite's broad capability in this specialized field is exemplified by the representative selection of lights shown here. Special modifications of basic designs can be custom-engineered to suit individual applications.

With complete production facilities plus an able design staff, Ucinite is ready to supply practically any requirement for indicators, connectors, switches and other small metal and metal-plastics assemblies . . . including stamped electrical circuits on flat or molded boards or housings.

A Lock-in front mounting. Non-removable.

B New square styling, front mounting.

C New reflector lens with excellent light dispersion characteristics.

D Specially designed for limited spaces. Fastens to a keyhole slot.

E New, tapered, protruding glass lens. Front mounting.

F Adaptable to virtually any type of lettering, monogram or other design. Lock-in bezel.

G Snap-in rear mounting for special applications where only lens is to show . . . . or can be used with an escutcheon.

H Bracketed mount adaptable to any multi-indicator application.

ELECTRICAL DOT ASSEMBLIES

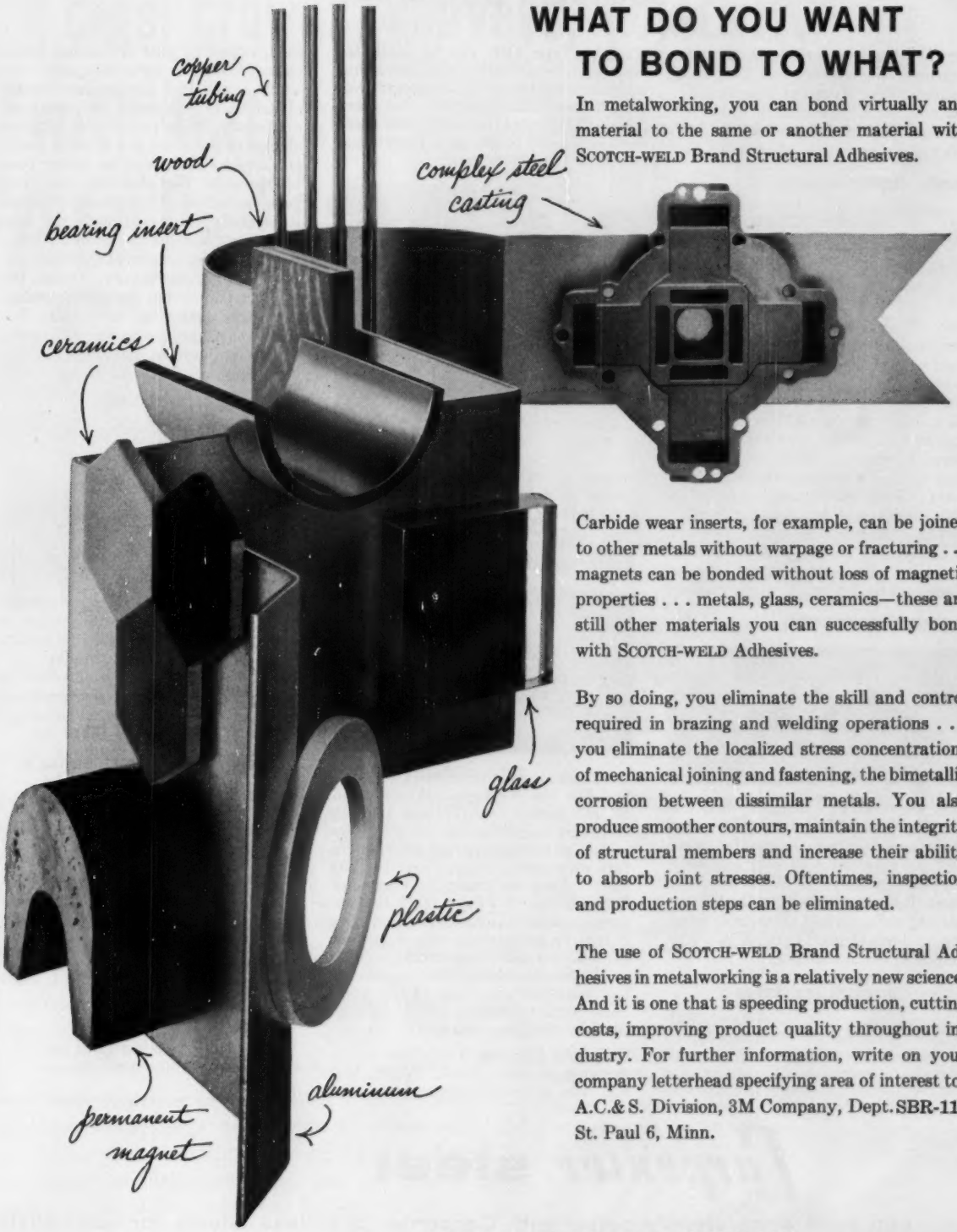
The UCINITE COMPANY

Division of United-Carr Fastener Corp., Newtonville 60, Mass.

Circle 437 on Page 19

WHAT DO YOU WANT TO BOND TO WHAT?

In metalworking, you can bond virtually any material to the same or another material with SCOTCH-WELD Brand Structural Adhesives.



Carbide wear inserts, for example, can be joined to other metals without warpage or fracturing . . . magnets can be bonded without loss of magnetic properties . . . metals, glass, ceramics—these are still other materials you can successfully bond with SCOTCH-WELD Adhesives.

By so doing, you eliminate the skill and control required in brazing and welding operations . . . you eliminate the localized stress concentrations of mechanical joining and fastening, the bimetallic corrosion between dissimilar metals. You also produce smoother contours, maintain the integrity of structural members and increase their ability to absorb joint stresses. Oftentimes, inspection and production steps can be eliminated.

The use of SCOTCH-WELD Brand Structural Adhesives in metalworking is a relatively new science. And it is one that is speeding production, cutting costs, improving product quality throughout industry. For further information, write on your company letterhead specifying area of interest to: A.C.& S. Division, 3M Company, Dept. SBR-110, St. Paul 6, Minn.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Circle 438 on Page 19

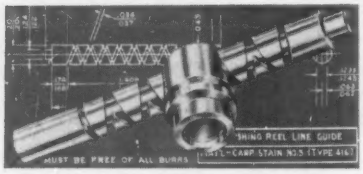
What **other** material gives you this **range** of desirable properties?

Here's a handy reference to the performance characteristics of Carpenter Stainless Steel. Tear out this information and file it. It may help you make the right decision in selecting the best material for your next assignment.

Greater hardness range

Only stainless steels can give you the combination of good corrosion resistance with sufficient range of hardness to meet any of your requirements. For example, fully annealed 18% Cr-8% Ni stainless steels such as Carpenter Stainless No. 4-A (Type 304) have a Brineil hardness of about 150, whereas heat treated Carpenter Stainless No. 440-C (Type 440C) can be as hard as 600 Brinell and both materials offer excellent resistance to a wide variety of corrodents. The range of hardnesses available with either copper-base or aluminum-base alloys is much smaller.

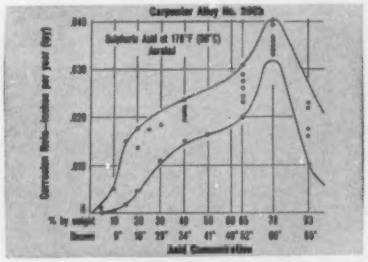
Superior machinability



The selection of Carpenter Stainless No. 5 (Type 416) for this level wind shaft for a fishing reel gave the manufacturer good machinability and eliminated expensive handwork on the shaft. It also provided excellent resistance to corrosion and unbeatable wearing qualities. A good example of a wise choice in metal selection.

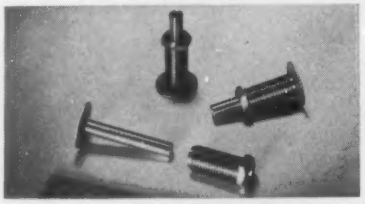
Better corrosion resistance

The wide range of stainless steels available offers the designer the exact degree of corrosion resistance necessary for almost any corrosive environment. For mild corrodents, inexpensive Carpenter No. 1 (Type 410) can be used; for extremely severe corrodents such as hot sulphuric acid solutions, Carpenter No. 20Cb should be specified. For other corrodents, one of the many other stainless steels will be the most economical material for you to use.



Carpenter No. 20Cb is a special alloy first produced by Carpenter in wrought form. Its excellent resistance to hot sulphuric acid is shown in the chart above. For information on its resistance to other corrodents, send for booklet, "Super Corrosion Control".

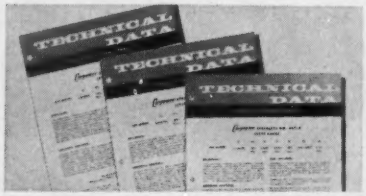
Easier quality control



Here's an application where Carpenter Stainless No. 8 (Type 303) provided an unexpected bonus! These bushing and shaft assemblies for a push-button unit in an explosion-proof switch were formerly made from a non-ferrous metal. After switching to Carpenter Stainless No. 8 (Type 303) to gain more uniform machinability and non-corrosive properties, this customer eliminated a costly inspection operation on the finished shafts. This was due to the consistently true size of the No. 8 bars (total tolerance: .0005" as supplied by the Carpenter mill).

Carpenter Stainless is available to the designer in many forms. Billets, bars and wire in a wide range of sizes . . . strip, tubing or pipe of varying thicknesses. Whatever form best suits your needs, you'll find one unique feature of Carpenter Stainless . . . its *consistent uniformity*. There's never the slightest change in composition in any one grade of Carpenter Stainless, no matter how big the order. Day after day, year after year, each melt of Carpenter Stainless is carefully controlled with the best equipment and human effort to bring you a reliable, consistent material, unsurpassed in uniformity. When the product you design goes into production, this consistent uniformity becomes extremely important. Specify Carpenter Stainless, and take a big step toward approval of your project.

Technical data available



Complete information on properties and characteristics of all grades of Carpenter Stainless is available in data sheet form. Send for yours today.

Are you getting all these performance characteristics in the materials you specify?

- ☐ *brilliant finish*
- ☐ *maximum strength*
- ☐ *corrosion resistance*
- ☐ *uniformity*
- ☐ *hardness*
- ☐ *versatility*
- ☐ *good machinability*
- ☐ *ease of fabrication*
- ☐ *exacting tolerances*
- ☐ *long service life*
- ☐ *customer satisfaction*

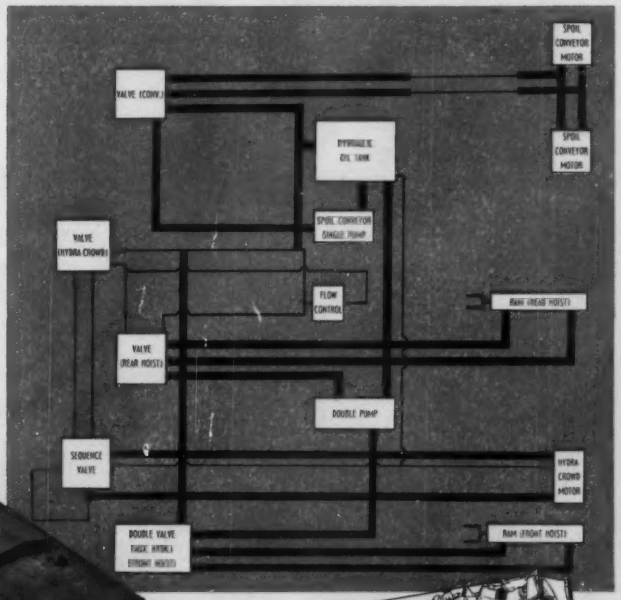
Carpenter Stainless gives you *all* these . . . and more!

Carpenter steel

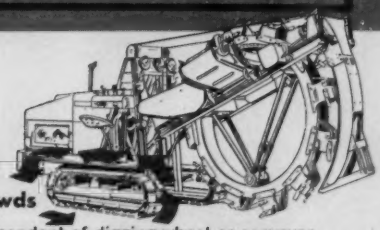
you can do it ***consistently*** better with Carpenter Stainless Steels for specialists

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

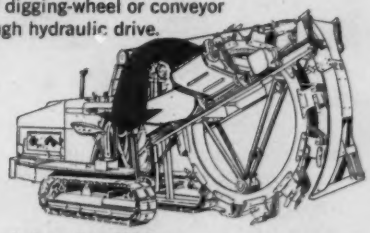
Barber-Greene's 'educated' wheel ditcher digs, crowds, conveys, hoists... with Gates Hydraulic Hose



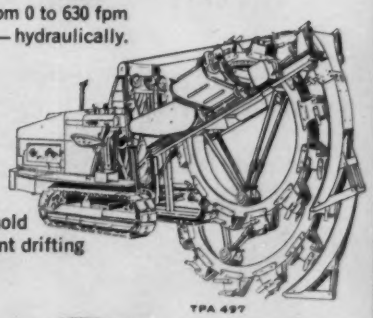
Digs
with maximum efficiency — thanks to exclusive Hydra-Crowd hydraulic transmission.



Crowds
independent of digging-wheel or conveyor speeds — through hydraulic drive.



Conveys
at variable speeds from 0 to 630 fpm with instant reverse — hydraulically.



Hoists
swiftly, positively to hold accurate grade, prevent drifting — hydraulically.

TPA 497

Developed specifically to "raise daily production and efficiency while lowering operating costs on ditching jobs," Barber-Greene's Model 772 Wheel Ditcher features *complete* hydraulic control of all operations — an important 'first' in the entire ditching field.

Of the Gates Hydraulic Hose used on the Model 772 Wheel Ditcher, Barber-Greene engineers have said: "Gates Hydraulic Hoses meet all of our rigid engineering specifications, and have operated to our satisfaction under the difficult conditions encountered in trenching work."

Immediately available in all major markets

Gates Hydraulic Hose — built to meet or exceed SAE specifications — is available nation-wide in wire-braided and horizontal-braided construction in a complete range of sizes, for medium-pressure or high-pressure use. Ask your nearby Gates Distributor for Gates Hydraulic Hose booklet, IH 43.

The Gates Rubber Company, Denver, Colorado
Gates Rubber of Canada Ltd., Brantford, Ontario

Gates
The Mark of Specialized Research

Gates Hydraulic Hose / Made in a Full Range of Sizes Medium-Pressure, High-Pressure

Circle 440 on Page 19

ENJAY BUTYL

IS TOPS IN ALL-'ROUND

RESISTANCE TO CHEMICALS

Enjay Butyl, because of its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. The preferred rubber for tank linings, hose, seals, gaskets and other applications where exacting chemical resistance is required.

VIVID COLORS

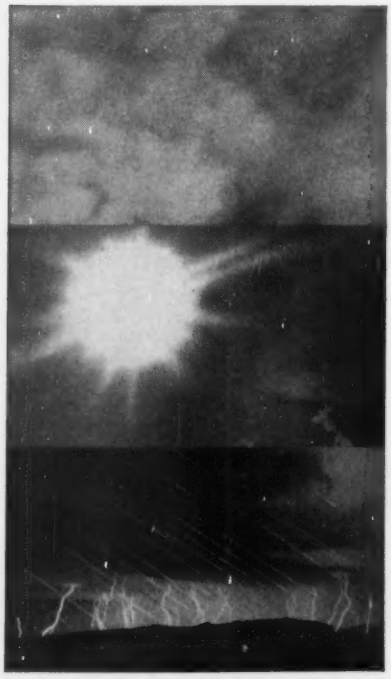
Enjay Butyl requires no additives for quality coloring over a wide range of hues. Famous for colorability and smooth finishes, Butyl has been successfully plastic coated for special applications.

RESISTANCE TO TEAR AND ABRASION

Enjay Butyl offers the highest aged tear strength of any rubber . . . even after long exposure to ozone and heat! Its inherent toughness resists abrasive wear, in such applications as tires, conveyer belts, hose and other mechanical goods.

RESISTANCE TO SUNLIGHT AND WEATHERING

Enjay Butyl has proven its resistance to ultra-violet light, ozone, oxidation, moisture and mildew. Increases life of products such as weatherstrips, garden hose, wading pools and automotive parts.



RUBBER

PERFORMANCE

DAMPING PROPERTIES

Enjay Butyl absorbs shock and vibrational energy more completely than any other rubber. Resiliency can be varied in compounding and processing. Butyl is ideal for axle and body bumpers, motor mounts and sound-deadening applications.

IMPERMEABILITY TO GASES AND MOISTURE

Enjay Butyl is tops in impermeability to gases and moisture . . . retains air pressure 8 times better than natural rubber. Outperforms other rubbers in such application as inner tubes, jar and bottle seals, hoses and inflatable goods.

ELECTRICAL RESISTANCE

Enjay Butyl tops all vulcanizable rubbers in electrical and dielectric properties . . . in resistance to corona and ozone breakdown and water absorption. Its high dielectric strength insures against electric breakdown under normal or surge voltage. Its heat resistance permits higher current flow for a given conductor size.

The outstanding properties of Butyl Rubber create new horizons for the designer, and offer to manufacturers an opportunity to utilize the qualities of rubber in applications never before possible. The unique properties of Butyl have led to vast improvement in many existing products. Technical skills will open the way to countless new uses.

Butyl is the "idea" rubber with uses stretching as far as the imagination can reach. We'll be glad to tell you all about it. Just contact the nearest Enjay office.

HOME OFFICE: 15 West 51st Street, New York 19, N. Y. OTHER OFFICES: Akron • Boston • Charlotte • Chicago • Detroit • Houston • Los Angeles • New Orleans • Tulsa

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

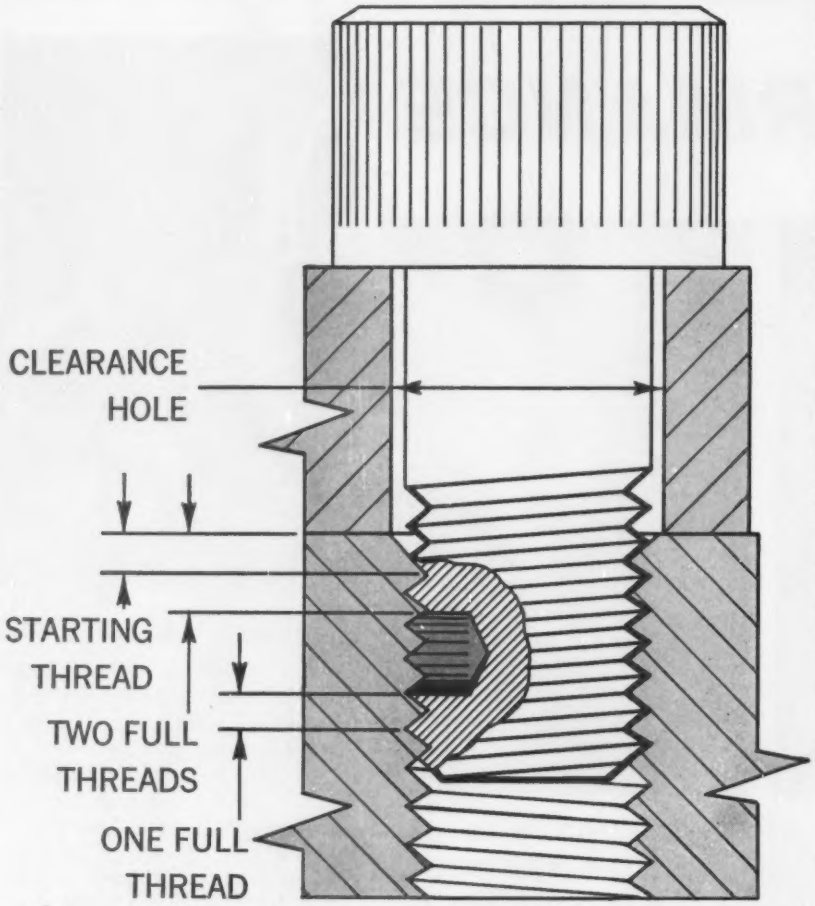
A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY® BUTYL

Circle 441 on Page 19

Only with **UNBRAKO**...

the pellet with positive locking power!



Note that the pellet covers only a portion of two threads and thus does not reduce the overall strength of the screw. Only a pellet — with its compact shape — can retain maximum thread area.

Nylok* principle means maximum thread area, maximum screw strength

To make UNBRAKO socket screws self-locking, a compact, resilient nylon pellet is inserted permanently in the threaded section of the screw. It forces mating threads tightly together, locking the screw securely, seated or not, wherever wrenching stops.

Why nylon for the locking medium? Its locking action is unaffected by use in water. It stays strong in cold or heat, does not become brittle down to—70°F, withstands continuous heat up to 250°F. It is unaffected by age or fungus, commercial solvents, alcohols, gasoline, oil, boiling 40% caustic soda. It will not dry out or shrink. It seeks to regain its original shape when deformed, a fact that makes it possible to reuse a screw repeatedly.

Now note specific ways in which self-locking UNBRAKOs benefit you:

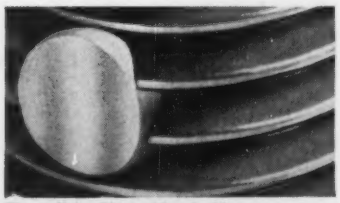
- Simplify design—shorter screws can often be used in tapped holes instead of drilling through and using nuts, lockwashers, cotter pins, or lock wiring
- Cut maintenance—by reducing time spent inspecting joints and tightening loose fasteners
- Cut downtime—won't budge even in the face of severe impact, shock, vibration

UNBRAKO socket screws with Nylok are easily removable and, above all, highly reliable. For complete information, see your authorized industrial distributor or write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.

INDUSTRIAL FASTENER Division
JENKINTOWN 18, PENNSYLVANIA

sps

where reliability replaces probability



The pellet with positive locking power!

*T.M. Reg. U.S. Pat. Off., The Nylok Corp.

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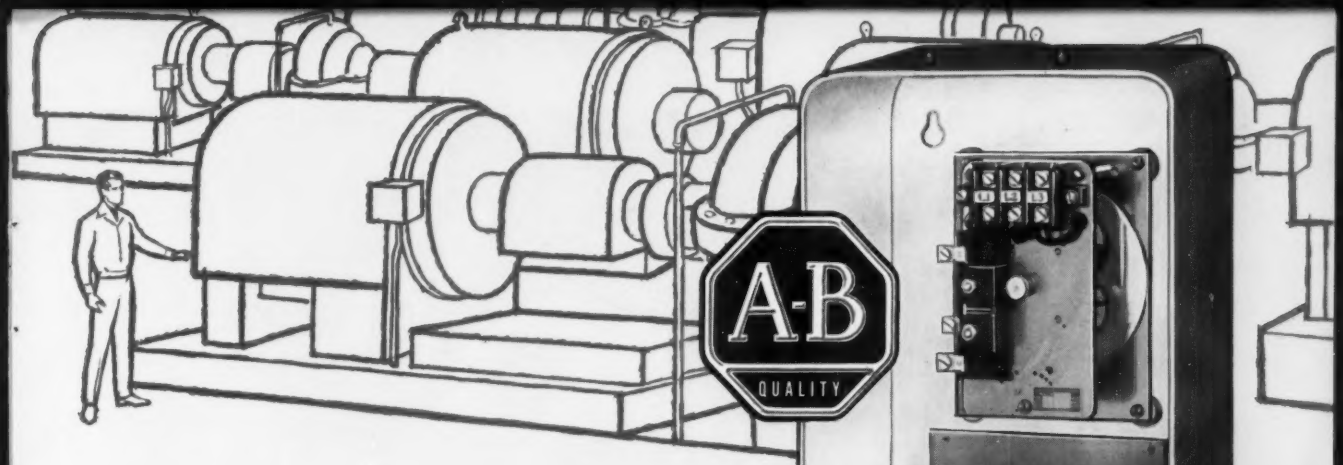
Circle 443 on Page 19→



ALLEN-BRADLEY PHASE FAILURE *and* PHASE REVERSAL RELAYS

will provide positive protection for high-horsepower, high-priced motors!

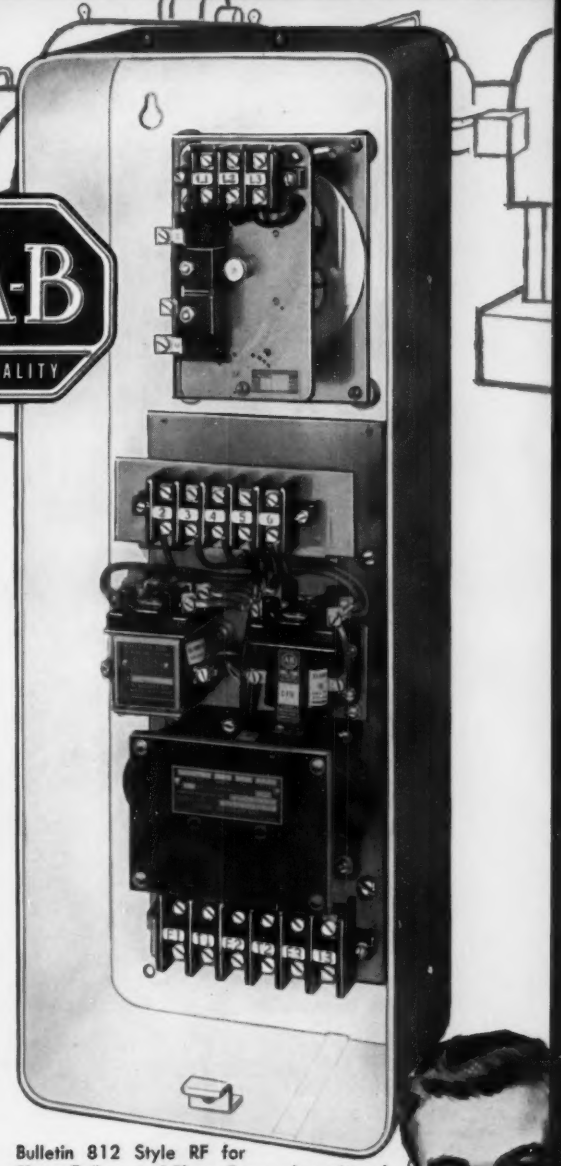
It's sound "economy" to guard your investment in expensive motors and equipment against the extensive damage that can result from a phase failure or phase reversal. Allen-Bradley's Bulletin 812 Style RF relay provides *complete, positive* protection against both of these hazards.

The Bulletin 812 Style F phase failure relay instantly detects *all* open phase conditions on a motor branch circuit and removes the motor from the line—yet is not subject to nuisance dropouts from transient line fluctuations. An unusual feature of this Style F relay is its positive response, regardless of motor load or type of motor branch circuit employed.

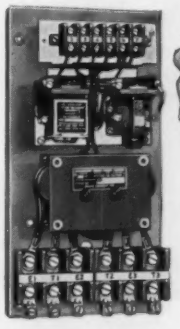
The Bulletin 812 Style R phase reversal relay disconnects the motor from the line—whether it is running or not—when a phase reversal occurs on the line side of the relay. Thus, it can be used to protect a single motor or a group of motors. Furthermore, the Style R relay removes the motor from the line should a phase failure occur while the motor is stopped.

All A-B Bulletin 812 relays are completely "fail safe." It will pay you to investigate this economical insurance against the heavy losses that can—and *frequently* do—result from phase failure and phase reversal. Write today!

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.



Bulletin 812 Style RF for Phase Failure and Phase Reversal consists of Style F Phase Failure and Style R Phase Reversal relays in the same enclosure.



Bulletin 812 Style F for Phase Failure

Bulletin 812 Style R for Phase Reversal

ET-60-R

ALLEN-BRADLEY

Member of NEMA

Quality Motor Control

ALLEN-BRADLEY
Solenoid Starters give

MORE MILLIONS OF TROUBLE FREE OPERATIONS

... and for good reasons

• ONE MOVING PART

With this simple solenoid design, there's virtually nothing to go wrong—all trouble-causing bearings, pivots, and flexible jumpers have been eliminated.

• DOUBLE BREAK, SILVER ALLOY CONTACTS

Allen-Bradley silver alloy contacts never require maintenance. They are always in perfect operating condition . . . and remain so until completely worn away.

• SIMPLE UP-AND-DOWN MOTION

The virtually frictionless, straight line vertical motion provides uniform contact pressure at all times—and assures consistent, rapid operation of the contactor.

• RELIABLE OVERLOAD PROTECTION

All A-B starters are equipped with two permanently accurate and reliable overload relays that protect motors against "burnouts." Three overload relays can be furnished.

BULLETIN 709 STARTERS are made in 9 sizes from Size 0 (at left) up to Size 8.

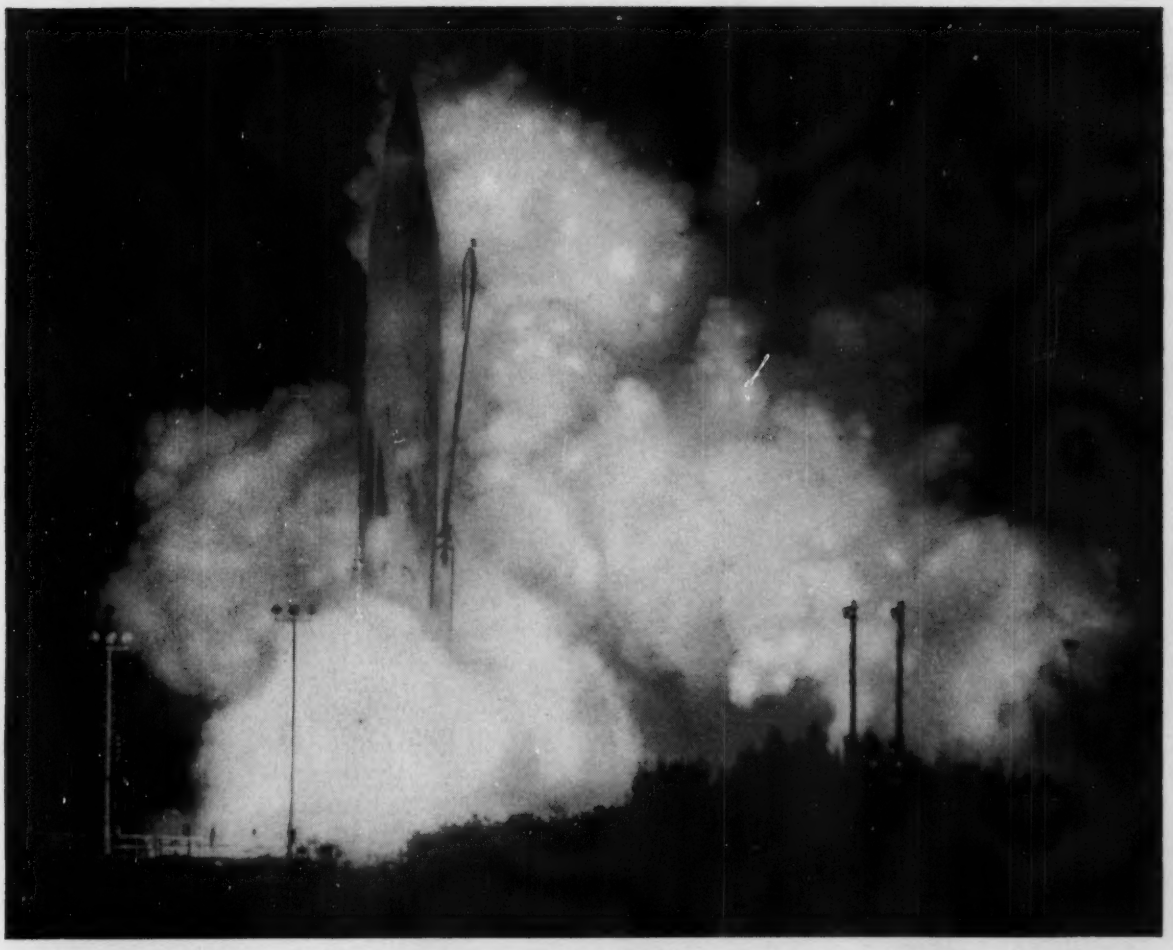
BULLETIN 709 SIZE 7 with maximum ratings of 300 hp, 220 v; 600 hp, 440-550 v.

ALLEN-BRADLEY

MEMBER OF NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL



Record breaking Atlas missile billows flame and vapor as she launches 4¼-ton satellite into orbit. Constructed of Type 301 Nickel Stainless Steel, Atlas is built by Convair (Astronautics) Division of General Dynamics Corporation. *U.S. Air Force photo*

130 tons of missile with a skin thinner than a window pane!

The Nickel Stainless Steel skin of the Atlas missile is actually about one-third as thick as the glass in your window.

And yet look what this skin does:

- It is the sole structural framework for Atlas—130 tons of dead weight at the moment of firing.
- It serves as the wall of the propellant tanks in Atlas' weight-saving design.
- It withstands the deep chill of liquid oxygen (−297°F) . . . the high heat of supersonic speed (400°F–600°F).

. . . And it is less than 1/25 of an inch thick!

No wonder they call stainless the space age metal. No wonder engineers turn more and more to Nickel Stainless Steel as temperatures rise . . . as speeds soar . . . as demands get more and more severe.

But Nickel Stainless Steel has many earthbound applications, too. Its strength and resistance to both corrosion and temperature extremes improves the performance and prolongs the life of many industrial products. And its attractive appearance provides still another reason for its popularity in products for the home.

What's your metal problem? Is it high or low temperatures? Corrosion, stress, fatigue or an unusual combination of factors? Write to us about it. Perhaps Nickel—or one of its alloys—can help you get it off the ground.

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.

INCO NICKEL

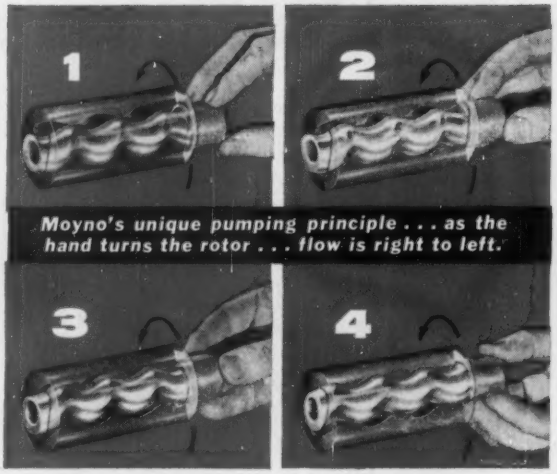
NICKEL MAKES STEEL PERFORM BETTER LONGER

New special application MOYNO® *pumps solve many product problems!*

Here is a completely new concept in small pumps. These Moynos successfully handle materials ranging from watery liquids and abrasive slurries to large particles in suspension. They use a single moving pumping element . . . have no pistons, valves, high-speed impellers or other quick-wearing parts. Moynos easily handle solids and abrasives that ruin piston pumps. They minimize sealing surface problems common to rotary pumps . . . don't cause foaming and aeration like centrifugal pumps do.

Moyno Special Application Pumps are available in two basic designs, each with or without direct-connected motor, in capacities up to 1200 gph and pressures to 300 psi. If your pumping requirements are so special that custom-designed Moynos are indicated, our engineers will examine your problem and recommend Moynos specifically suited to your needs.

Write today for copy of new Moyno bulletin 55-MD



Moyno's unique pumping principle . . . as the hand turns the rotor . . . flow is right to left.

ROBBINS & MYERS, INC., Springfield, Ohio

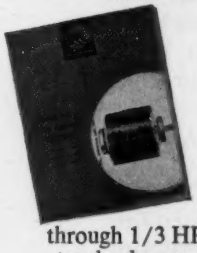
Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 444 on Page 19

MOTORS

special application

if special application FHP motors are on your mind... write for R&M's new Bulletin 445

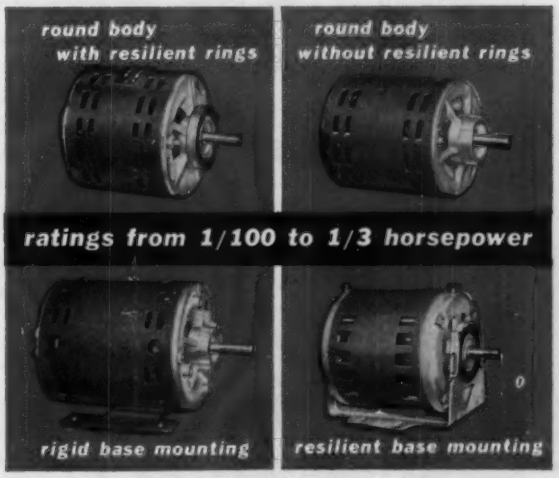


This informative bulletin illustrates and describes in detail Robbins & Myers broad new line of Special Application FHP Motors.

You may select from four frame sizes, sixteen ratings from 1/100 through 1/3 HP, three different pole constructions, three standard mounting arrangements and four electrical types.

Simple, compact and quiet, these motors offer built-in benefits for your customers, as well as design flexibility for you, where silent operation, limited mounting space and minimum attention are factors.

Also, should your requirements be so special that a custom designed motor is indicated, our expert application engineers, using the most modern electronic computers, can promptly select the optimum design for your special requirements. Write today for your copy of R&M's new bulletin 445-MD


round body with resilient rings
round body without resilient rings
ratings from 1/100 to 1/3 horsepower
rigid base mounting
resilient base mounting

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 445 on Page 19

NEW... AND AVAILABLE

"LUBRI-AIR"®

FILTER, AND LUBRICATOR

METAL BOWL UNITS

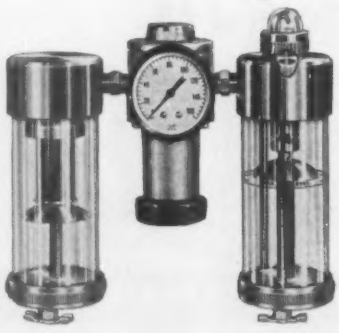
VISIBLE OIL LEVEL

VISIBLE OIL FLOW

INTERCHANGEABLE

with "Lubri-Air" plastic bowl units

Pat. Applied for



New metal bowl "Lubri-Air"® Filters and Lubricators are obtainable in ¼" and ⅜" port sizes, with immediate delivery. Other sizes will follow. Conversion units for ¼" and ⅜" plastic bowl "Lubri-Air" units are also available. Write for Sales Manual LA-20M . . . Dept. MD-1160, Bellows-Valvair, Akron 9, Ohio . . . or, call your Bellows-Valvair Field Engineer.

Without losing the feature of "VISIBILITY OF CONTENTS" which gives plastic Filter and Lubricator bowls a universal appeal, the new Sight Glass-Metal Bowl units offered by Bellows-Valvair eliminate the hazards caused when plastic containers break down from chemical action. "Lubri-Air" aluminum Filter and Lubricator units may be used for higher pressure, higher temperature applications than plastic bowls; they are not affected when fire-resistant oils are used in compressor or lubricating systems. The sight glass has wide angle visibility for easy level reading . . . Lubricators (unit shown above) have a tempered Pyrex glass dome for quick determination of oil flow.

917C

Bellows-Valvair

Bellows-Valvair

AKRON 9, OHIO

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

INVESTMENT CASTINGS

small
or
large

in any metal--ferrous or non-ferrous, including magnesium
in any quantity--production or prototype

Arwood's casting facilities enable us to cast parts that range from a fraction of an ounce up to 100 pounds. You now have a single source for small and large castings. It's just another good reason for doing business with Arwood.

- Five production plants throughout the country.
- Complete design, tooling and metallurgical research facilities.
- Eighteen years' experience in casting *all* the metals and alloys that can be poured into a mold – including everything from magnesium right through to stainless steel and difficult-to-machine superalloys.
- A time-tested record for reliability in meeting quoted prices and scheduled deliveries.
- Seventy-one trained engineering representatives coast to coast.

So . . . when the specifications call for an investment casting, you'll find that it pays to get a quote from Arwood.

Like to know more about investment casting? Send for our 44-page "Practical Guide to Investment Casting." It's yours for the asking.

Machine the simple . . . cast the complex

A complete service from design through tooling, production and finish machining. Seventy-one engineering representatives from coast to coast.

arwood

ARWOOD CORPORATION • **315 West 44th Street, New York 36, New York**
PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.

Circle 447 on Page 19

"ALCOA ALUMINUM SCREW MACHINE STOCK ALLOY 2011 CUTS YOUR UNIT COST!"

Precision-made, high-volume screw machine parts cost less in aluminum

Final cost of your machined component . . . material cost plus production cost . . . is *lower* with Alcoa Alloy 2011-T3. That's because this faster machining alloy cuts production time . . . machines easier . . . can be held to close tolerances . . . gives a bright, clean finish. And Alcoa® Aluminum 2011-T3 gives you three times as many parts per pound as other, heavier metals, for still more savings. By using Alcoa Aluminum 2011-T3 Screw Machine Stock you get all the inherent advantages of automatic screw machine products.

Be sure to ask your Alcoa distributor or Alcoa sales office for your free *Alcoa Conversion Calculator*. It makes cost conversions from brass to aluminum quick, easy, finger-tip operations. Also get your free *Alcoa Screw Machine Stock Estimating and Operating Data Book*, the most comprehensive book of its kind in the screw machine field . . . packed with easy-to-find technical data.

You'll want information, too, on other Alcoa screw machine alloys: 2017-T4 or -T451 for strength at low cost, 2024-T4 or -T351 for strength with high production, and 6061-T6 or -T651 for superior finishes, excellent joining characteristics and extra corrosion resistance. Aluminum Company of America, 840-L Alcoa Building, Pittsburgh 19, Pa.

ADDITIONAL BONUSES YOU GET WITH EVERY ALCOA ALLOY:

1. Wide range of stock sizes for important price advantages.
2. Guaranteed market for up to 60 per cent of your Alcoa Aluminum turnings and borings.
3. Extensive mill and distributor inventories to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).

ALCOA ALUMINUM

SCREW MACHINE STOCK

Circle 448 on Page 19

New

ROTO-MISSION
TRADE MARK

PATENTED

Most versatile transmission ever developed!

ONLY ROTO-MISSION GIVES YOU ALL THESE FEATURES

- Concentric configuration
- Minimum size for a specified torque
- Reduction ratios up to 270:1
- Optional torque capacities for each reduction ratio
- Torques up to 21,850 lb.-ft.
- Requires neither driving pulley nor coupling
- Casehardened helical gears—ground after hardening for perfect engagement
- Reversible
- Progressive overload capacity to the extent that no breakage of gears can result even from the severest abuse
- *Ability to engage or disengage driving action —mechanically, pneumatically, hydraulically or electrically
- *Ability to provide load releasing, load limiting or overload alarm
- *Ability to provide 2-speed operation

*Standardized accessories to provide these features are available for all sizes of Roto-Mission from stock. This results in a single responsibility for installation performance.

This new rotary transmission design combines a wide range of reduction ratios, high torque capacities, and excellent space-saving characteristics to give you more application versatility than ever before possible. It is designed to be concentrically mounted on a machine drive shaft in place of the drive pulley and operate this shaft at a reduced speed from that of the driving motor. For maximum compactness and convenience, all its parts are inside the casing.

The standard accessories available for each model of Roto-Mission add even greater versatility. Through them you have systems—from a single source—capable of control functions that previously required a number of unmatched units from several suppliers.

Because of its versatility and sound engineering, Roto-Mission permits you to solve design problems far beyond the range of other transmissions —may even permit incorporation of features in your machines that have not previously been possible. For complete information on this new product—how it operates and how it can help you —write today for Catalog IR-60.

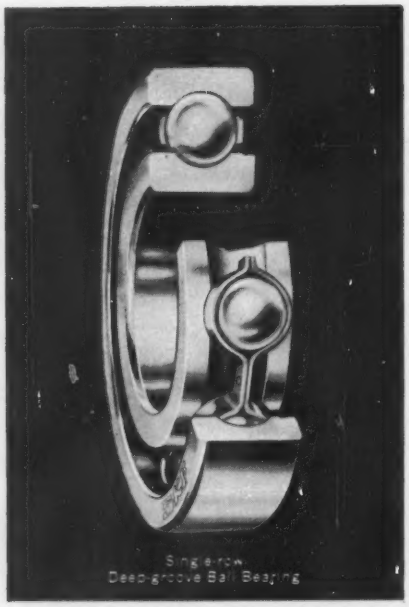
AIRBORNE®

Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

Circle 449 on Page 19



Can a standard bearing offer you "more bearing" for your money?

It can if it's made by SKF—because all SKF bearings, both ball and roller, offer special qualities at "production" bearing prices.

Take the single-row deep-groove ball bearing featured here, as an example. SKF designs and builds this type to sustain heavy radial load and thrust load in either direction. Furthermore, it is engineered to run smoothly and quietly at normal speeds with grease lubrication—and at high speeds with oil.

Yet this is a standard SKF ball bearing, mass-produced by automated production equipment at our plant at Altoona, Pa. You can quickly get this bearing in over 100 sizes, ranging from ⅝" to 15.748" O.D., and in a variety of seal, shield and snap-ring combinations.

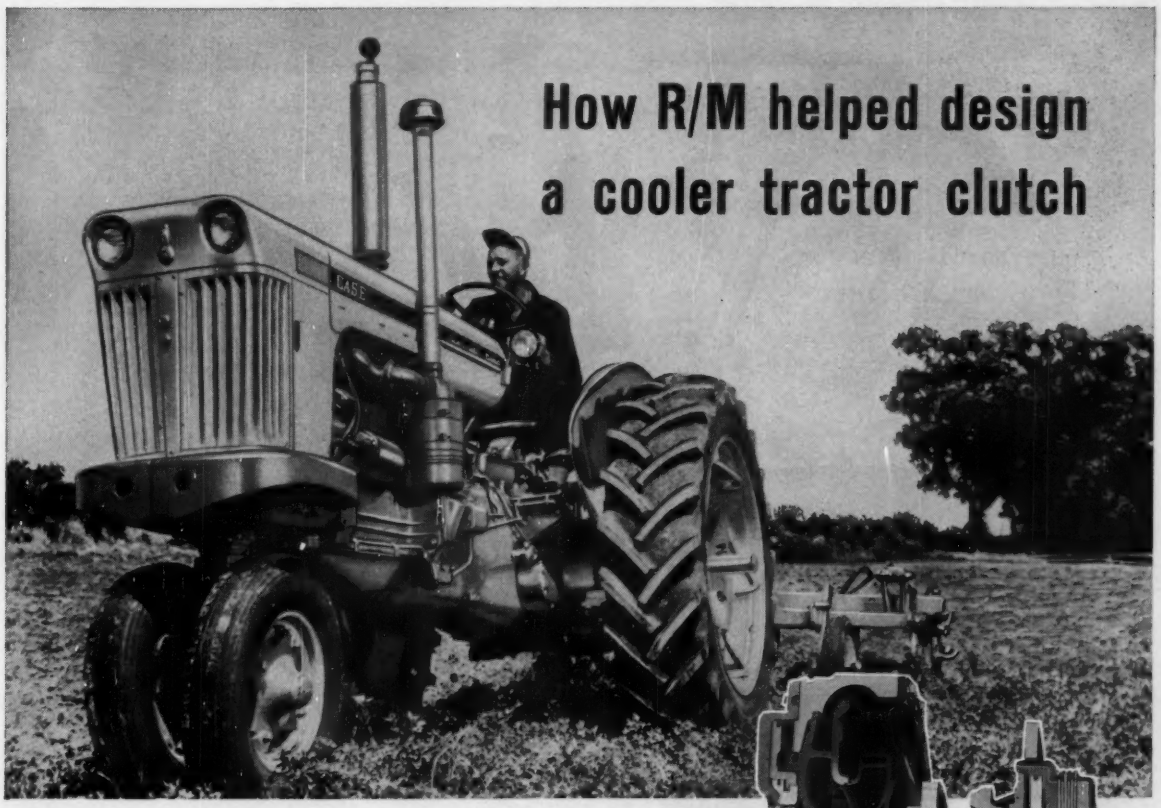
But why not find out what SKF offers in bearing quality, availability and economy? Just call the SKF branch office nearest you.

6001

Spherical, Cylindrical, Ball, Tyson Tapered and REED Miniature Bearings
EVERY TYPE—EVERY USE
SKF
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

Circle 450 on Page 19

How R/M helped design a cooler tractor clutch



Case-o-matic Drive torque-converters on J. I. Case tractors use waffle-grooved R/M sintered bronze friction material in master clutch.

Improved heat dissipation in a forced-cooled clutch resulted from close co-operation between engineers of Twin Disc Clutch Co., Racine, Wis., and Raybestos-Manhattan.

Waffle grooving

As a manufacturer of all types of clutches, Twin Disc has wide experience in the useful application of friction. This knowledge, combined with R/M's friction know-how and laboratory and research facilities, produced a clutch plate of sintered bronze with waffle-type grooving, which improves cooling and lubrication.

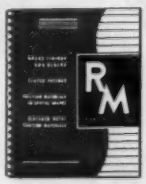
Three of these friction plates are used in master clutches of Case-o-matic Drive torque-converter transmissions manufactured by Twin Disc for J. I. Case farm tractors.

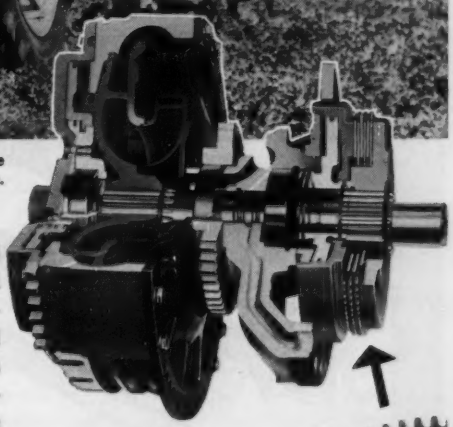
For over 20 years, R/M has worked with every kind of friction material for thousands of specialized applications. Only R/M manufactures all types of friction materials. For this reason you can be sure you are receiving *sound, unbiased advice from R/M on the material best suited to your application.*

Outstanding service

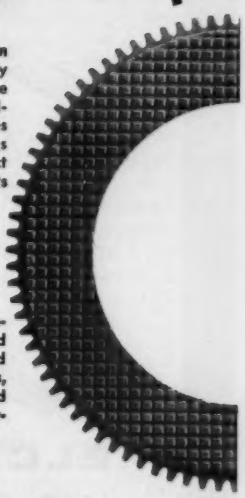
Why not take advantage of R/M's broad experience and outstanding service—an R/M sales engineer can be at your desk within 24 hours.

Want helpful engineering data on friction materials? Send now for R/M Bulletin 501—no obligation.





Unique clutch design revealed in cutaway of Case-o-matic Drive transmission. Balanced-piston system eliminates clutch release springs and provides compact design. Arrow points to clutch plates.



Waffle grooves improve cooling and lubrication. Sintered bronze friction facings, .022 in. thick, bonded to a 14 gage copper-plated base plate.

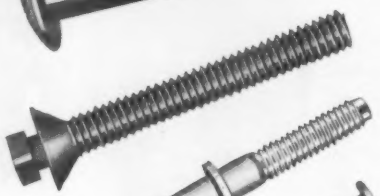
RM

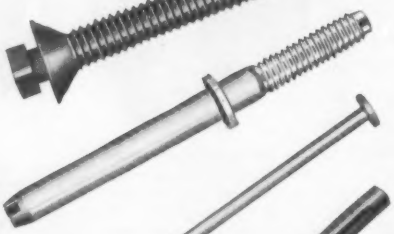
RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION: Bridgeport, Conn. • Chicago 31 • Cleveland 16 • Detroit 2 • Los Angeles 58

ELCO®

COLD-HEADED SPECIAL PARTS





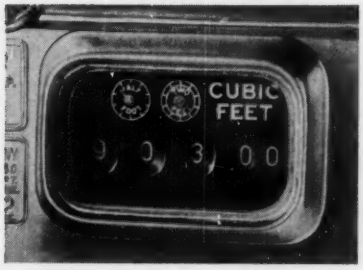
Substantial savings are often achieved through the use of low-cost cold-headed parts in place of complex assemblies or pieces requiring several machining operations. The examples shown here represent a wide variety of possibilities, yet these are only a few of the thousands we have produced. Our sales engineers and field representatives are ready to give you skilled advice on potential adaptations to *your products. Just call your Elco man.*

ELCO TOOL AND SCREW CORPORATION

1119 SAMUELSON ROAD, ROCKFORD, ILLINOIS

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING



YES, WE HAVE NO GASKETS

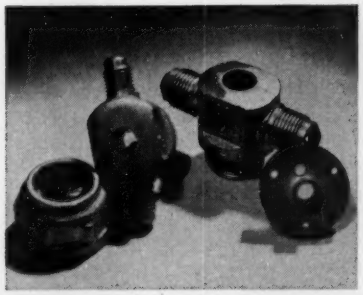
Gaskets cause countless problems in sight glasses, people told us.

Get rid of the gaskets, we replied.

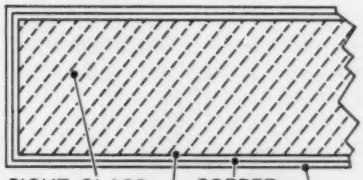
Show us how, they retorted.

So, we did.

Two ways.



One. We can and do make valve windows wherein the glass is fused directly to the metal without aid of gasket or solder. The result is a one-piece assembly with an heroically hermetic seal rated at 700 psi and bursting strength around 2500 psi.



Two. When it makes sense, we can and do metallize a glass with a base coat of silver, electroplate it with copper, and face it with a coat of tin which accepts soldering to a bezel, which we also can and do do. The finished window is rated to take 15 psi inside or out.

Since we are as versatile as the material we work with, we can pull such tricks as pressing configurations into the windows. We've already done things like bull's-eyes and indentations.

We had another job where we pressed an optical lens into a glass. The focal length of the lens is such that you get a reflection of light back to your eye, except when the unit is full of liquid, in which case you focus on the liquid itself.

Look into our windows whenever you find a gasket a nuisance, whether from temperature or pressure or corrosive environment or any of the many other conditions which tend to make gaskets a nuisance.

You can begin looking by sending the coupon.

ON ENCAPSULATING WITH PYROCERAM® CEMENT

Should you want to lift the thermal ceiling on encapsulated electronic parts as high as 700°C., you'll like what you see when you take a look at our PYROCERAM cement No. 45.

Certain people making coil cores for hot work are finding it almost ridiculously easy to meet such temperature specs while holding performance in all other areas.

The cement is almost completely impervious to vapors and chemically inert. It matches nicely to tungsten, molybdenum and other materials with a coefficient of expansion from 40 to 50 x 10^{-7}/°C.

This same cement can also be used for sealing glass to glass, metal to metal, ceramic to ceramic, or any combination of these materials.

There are two other PYROCERAM cements, both of which have a service temperature of 425°C. No. 89 lends itself well to platinum, vanadium, 50% nickel, and other materials with a coefficient of expansion 80 to 92 x 10^{-7}/°C. No. 95 is for chrome-iron stainless, Sylvania No. 4, and the like with a coefficient of expansion 90 to 110 x 10^{-7}/°C.

People who know say that the applications for this new material are ready to snowball. Perhaps if you send the coupon now, you will be first to use it in your particular field.

VYCOR® GLASSES AS WATER-GETTERS OR PROBE PROTECTORS

Put a piece of porous VYCOR brand glass into a humid environment and it drinks up 25% of its weight in moisture before becoming sated.

This has suggested its use as a substitute for desiccants to a number of people, particularly people who want a getter with unusual rigidity under stress conditions. Say, in a sealed inert-gas gyroscope, for example.

Others have seen in this same 96% silica glass a clean, long-lived semipermeable membrane.

Put a tiny tube of VYCOR non-porous glass around a pair of thermocouple wires and you have a device for reading the temperature of working melts of metals or anything else that runs from 2000 to 3000°F.

The tubes will stand up from four to six seconds even under this intense heat, keeping the wires intact long enough to get an accurate reading.

Actually, in practice these tubes are emerging from metal melts marred but still intact two times out of three! Since the glass is 96% pure silica, there's no threat of contamination to the melt even if the tubes should disintegrate.

All of which serves to demonstrate just two of the many amazing properties of the VYCOR brand glasses.

There's more about the various VYCOR glasses with their varied properties and the sizes and shapes we can deliver in a bulletin which is mentioned in the coupon.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS, 5211 Crystal St., Corning, N. Y.

☐ Sight Glasses ☐ VYCOR ☐ PYROCERAM Cement

Name..... Title.....

Company.....

Street.....

City..... Zone..... State.....

Circle 453 on Page 19

PACKINGS and SEALS
in Design
Engineering

Designers find that, regardless of the size or complexity of sealing problems, the best solution lies with engineered Garlock products.

On small, 10 g.p.h. centrifugal pumps or on huge 4000-ton hydraulic presses, Garlock packings and seals do an outstanding job of retaining fluids longer, more economically, and with less trouble and downtime.

For rotary shafts, Garlock PK MECHANIPAK* Mechanical Seals are easy to install and maintain. They are completely self-contained . . . no parts to put together. Rotating portion positions quickly. No parts of the seal move on the shaft or sleeve, eliminating wear on the shaft. Garlock PK MECHANIPAK Mechanical Seals operate at temperatures to 212°F, pressures to 150 p.s.i. in water, oil, alcohol, mild acids and solvents. They are available in shaft sizes from ⅜" to 3" for shaft speeds up to 2000 f.p.m. and higher. Catalog AD-150.

For rams, plungers, and reciprocating rods, Garlock CHEVRON* Packings offer positive, low friction service. With an exclusive hinge-like construction, CHEVRON packing rings tighten to prevent leakage as pressures increase. When pressures decline, the rings ease off to permit free operation of the rod, ram, or piston without leakage. CHEVRON packing rings provide adequate heel clearance for easy installation. Once installed, further gland adjustment is rarely, if ever, necessary. Apply against water, steam, oil, gases and chemicals to 600°F. Catalog AD-115.

GARLOCK

In the design stage of industrial equipment and systems, call in your local Garlock representative. Take advantage of his years of experience—he has many suggestions on ways to achieve greater customer satisfaction through good sealing practice. Call him at the nearest of the 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for catalogs indicated. Garlock Inc., Palmyra, New York.

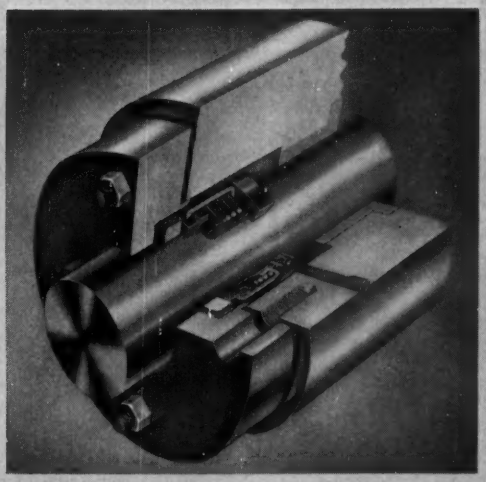
Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Co.

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastics Products

*Registered Trademark

Circle 454 on Page 19



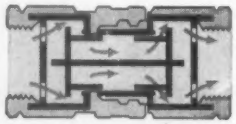
Specify Garlock PK MECHANIPAK Mechanical Seals for centrifugal pumps, automatic washing machines, gear boxes, dishwashers, speed reducers.

Apply Garlock CHEVRON Packings on hydraulic and pneumatic equipment like power cylinders, drawing and forging presses, hydraulic pumps.

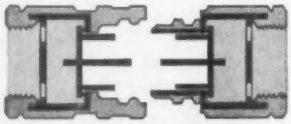
Hey, Herman... Snap-Tite valved couplings come in big sizes too!

There's a size and type to handle almost anything that flows

TO USE SNAP-TITE VALVED COUPLING:



CONNECT—Full flow instantly



DISCONNECT—No flow instantly

Snap-Tite can provide the right size valved coupling for most any use . . . with quick off-on action wherever coupling or shut-off is required.

"H" series valved couplings for high pressure applications. High resistance to heavy line surge. Sizes from 1/8" through 6". Larger sizes on special order.

"IH" series valved couplings for greater impact in air lines. 1/8" through 1/2".

"E" series valved couplings for vacuum and very low pressure. Recommended for gravity flow. Sizes from 1/8" to 6". Larger sizes on special order.

"T" series valved couplings for hard to handle fluids. The only valved quick-disconnect couplings now on the market for fluid temperatures from −40°F to +400°F. Sizes from 1/2" through 3".

Snap-Tite valved couplings are available with two-way or one-way automatic line shut-off. They are normally furnished in alloy steel. Also available in brass, aluminum, or stainless steel with a variety of finishes.

Write for Snap-Tite Catalog No. 58 for more information on Snap-Tite valved couplings.

Snap-tite
UNION CITY 11, PA.

ST-58-02

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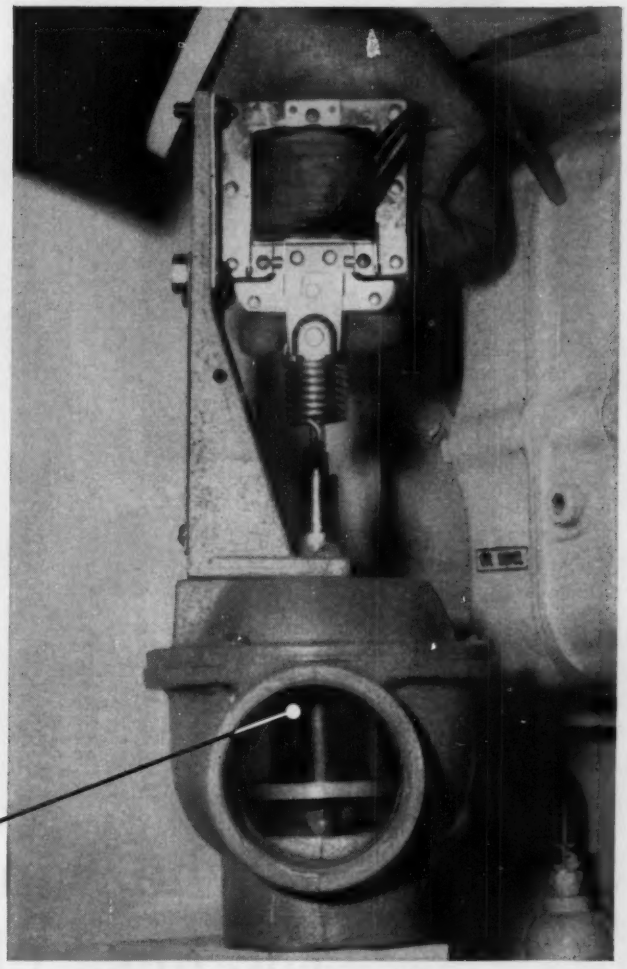
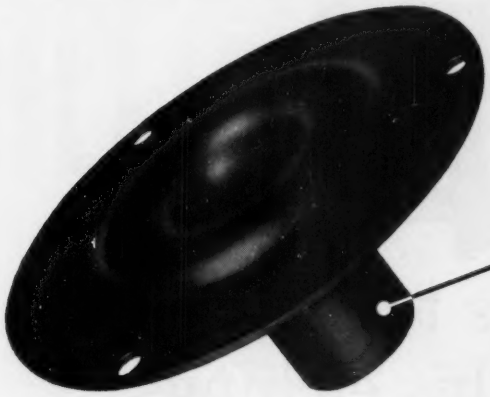
Another new development using

B.F.Goodrich Chemical *raw materials*



Willard drain valves, using a diaphragm molded of Hycar by Immel Engineering, Dallas, are used in commercial washing machines manufactured by Cook Machinery, Inc., also of Dallas. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.



Detergents tough on rubber parts as well as dirt

...till Hycar solved the problem

The drain valve for these commercial washing machines is controlled by a solenoid through a rubber diaphragm. Chemicals commonly encountered in soaps and detergents created a problem—till these diaphragms were made of Hycar nitrile rubber.

Hycar is a tough rubber—unaffected by hot water, excessive alkalinity or chemicals. It resists oils, greases, and other hydrocarbons, retaining its resilience and flexibility over a wide temperature range.

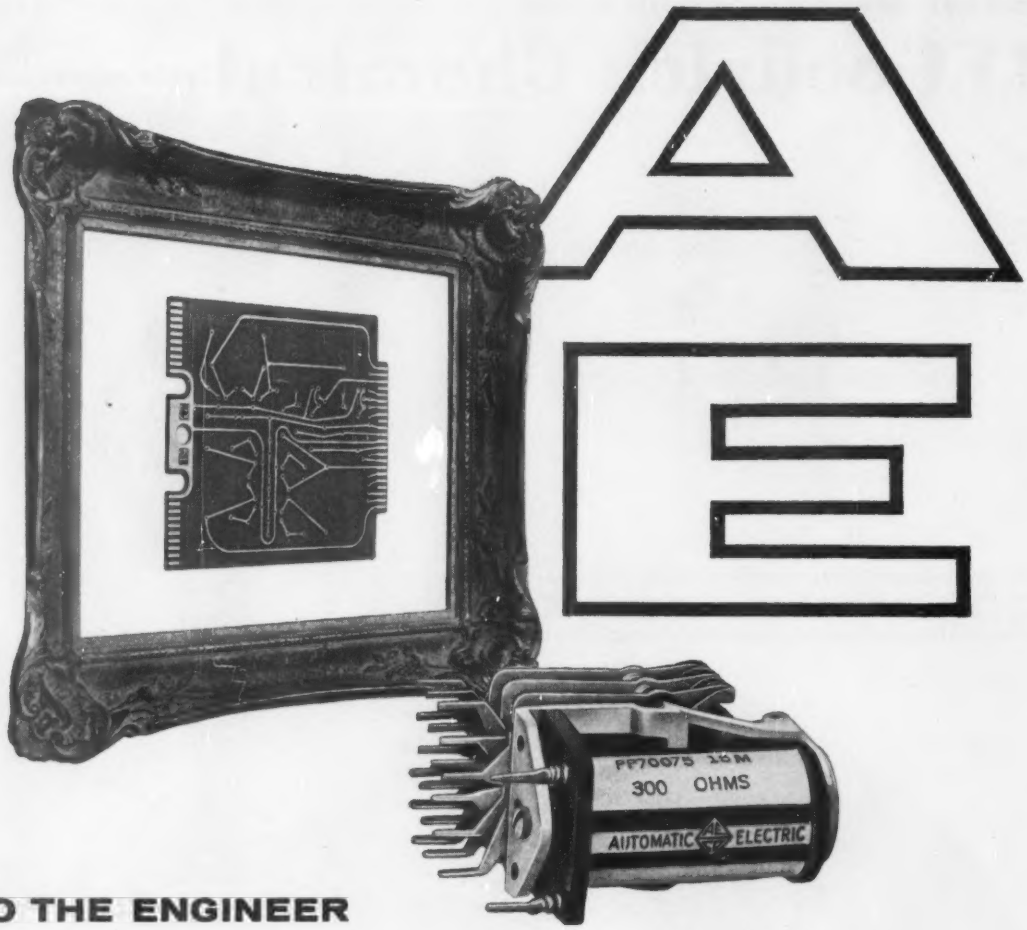
Next time you have a rubber problem to solve, it may pay you to know about the unique advantages Hycar brings. For more information, write Dept. FO-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar

Rubber and Latex

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers



TO THE ENGINEER

who wants to make the most of his etchings

If your printed circuit board designs involve switching, you can count on getting the best results by using AE Class E relays with direct-connect terminals.

Series EQPC relays, with end-mounted printed circuit lugs, occupy a minimum of board space, and furnish dramatic savings in assembly and wiring time.

The AE Series EQPC printed circuit relay is a miniaturized version of the premium-quality Class B telephone-type relay, with many of its best features. Contact reliability exceeding 200 million operations can be expected.

Automatic Electric also supplies Class E relays with Taper-Tab terminals, and prewired for plug-in, with 8- to 20-prong octal plugs, with or without hermetically sealed containers or dust-tight housings.

Want details? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1702-E on *Relays for Industry*, and the new *Conversion Factors* booklet.

AE CAN DO

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

Circle 457 on Page 19

Circle 458 on Page 19→

SOLD BY THE MILLIONS

KEYSTONE MB SPRING WIRE STUDY

Western Newell Mfg. Co. also supplies a complete line of drapery hooks made from Keystone Forming Quality Wire.

Newell

depends on KEYSTONE WIRE in the production of low-cost spring sash rods

To mass produce low-cost items that sell by the millions to retail stores coast to coast, calls for a quality product with top eye appeal for customer acceptance. Western Newell Mfg. Co., Freeport, Illinois, branch of The Newell Companies, manufactures many such items, including the spring sash rod illustrated. Keystone Drawn Galvanized MB Spring Wire permits continuous, mass-production runs without rejects . . . essential for profitable operation.

Says John H. Hepner, Purchasing Agent for Western Newell, "Keystone helps us produce a better sash rod through their close cooperation in developing and maintaining a wire most suitable for our use."

The most important requirements for manufacturing their sash rod are uniformity of temper throughout the coil, plus the superior silver brite luster of Keystone Drawn Galvanized MB Wire.

Keystone metallurgists carry on a continuous research for better spring wire so that Western Newell can hold a cost advantage. Such service has made this company a long-time user of Keystone MB Spring Wire.

You, too, can take advantage of Keystone's experience to mass produce your product with wire. For more information, talk with your Keystone Wire Representative. He will be pleased to serve you.

Keystone Steel & Wire Company, Peoria, Illinois

KEYSTONE

WIRE FOR INDUSTRY

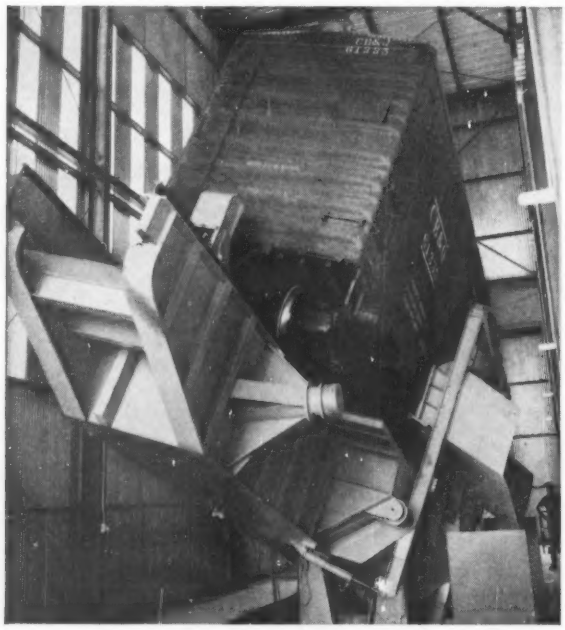
IN HYDRAULIC DESIGN

Use the IMO Pump for your high capacity requirements

Big money, space savings—single IMO pump delivers up to:
3000 gpm @ 300 psi • 900 gpm @ 500 psi
400 gpm @ 1250 psi • 275 gpm @ 3000 psi

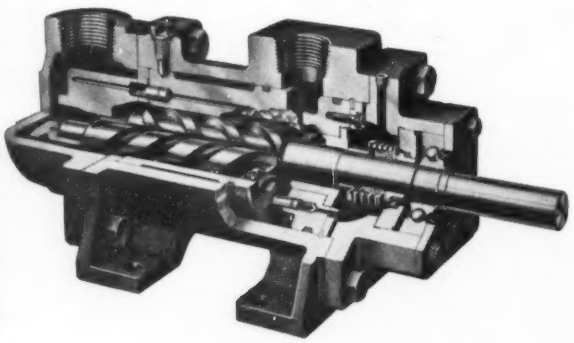
The De Laval IMO pump is unique. It may often replace two or more other type pumps in your design because of its high capacity. In the illustration shown here, the IMO pump is used to actuate a freight car unloader, designed by Straight Engineering Company. In addition to high capacities in a single pump, the IMO also gives you:

- Quiet operation—the proven pump for hydraulic elevators.
- High speed operation without sacrificing performance—ideal for 3500 and 1750 rpm motor speeds.
- Least pulsation of any rotary pump—ideal for machine tool applications.
- Dependable, long life operation—"the" pump for critical services on naval vessels.
- High suction lift capability—eliminates need for supercharging.
- Rugged design—nodular iron case utilized for pressures over 500 psi.
- Exceptionally high mechanical efficiency—means longer pump life.



The IMO has been time-tested and proven in the following applications: machine tools, presses, fan drives, pumping jacks, elevators, water level controls on dams, turbine governor controls, furnace controls, fire trucks—to rotate and raise ladders, and hydraulic systems for the U. S. Navy.

If you want more information on the versatile IMO pump, write for Bulletin 3200.



DE LAVAL **STEAM TURBINE COMPANY**
858 NOTTINGHAM WAY, TRENTON 2, N. J.

DL 223

ALLIS-CHALMERS

POXEAL insulation in this SUPER-SEAL motor needs no bake-out after floods.

Here's an open motor that shrugs off flood damage! Proof of

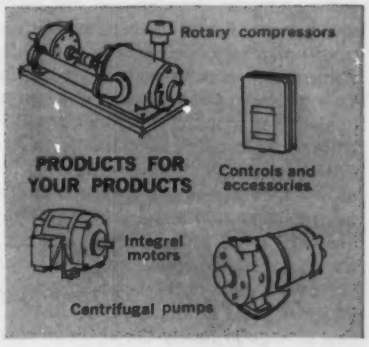
O.E.M.pathy*

***O.E.M.pathy . . . a unique form of empathy . . . the sensitivity to understand and to react to the problems of Original Equipment Manufacturers.** Because we are an OEM ourselves, we have this sensitivity. It means, "We give what we'd like to receive."

In terms of research, O.E.M.pathy results in unusually good components . . . like the motor shown above. It produces components that improve your product's performance and salability, saves time and reduces service needs. O.E.M.pathy also means regional stocking near your plant, complete product lines and competent service of national scope.

It's more than a desire to serve. It's the proven ability to serve you as an OEM. At Allis-Chalmers, we want your components business. We'll work to get it and we'll work to keep it. **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin.* A-1340

Poxeal and Super-Seal are Allis-Chalmers trademarks.



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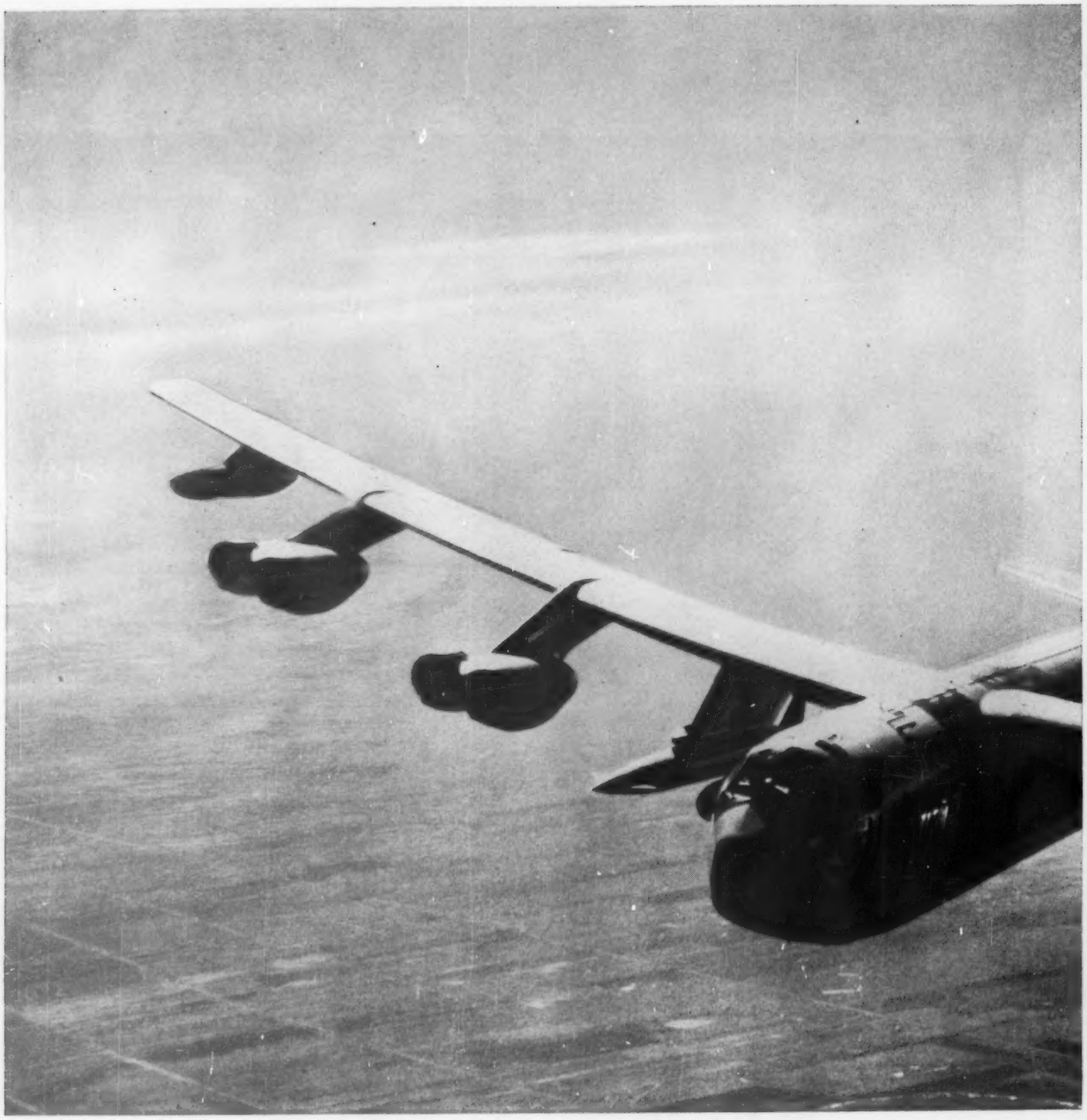


The BOEING B-52G triple-threat nuclear bomber — a major weapon in the current SAC deterrent force—recently carried two big missiles over the North Pole on a 10,800-mile nonstop flight. The flight was another example of a successful effort by the SAC-industry team to provide constant refinement and maintenance of the Strategic Air Command's "big stick" fleet of heavy and medium jet bombers. Designed originally as a platform bomber, the B-52G can now carry, in addition to its bomb load, two North American "Hound Dog" GAM 77 missiles capable of tracking down targets hundreds of miles from their launching point. This makes it possible for the big ship to strike at three entirely separate targets in one raid. The B-52G transports a gross weight of nearly half a million pounds, and Alcoa® Extrusions help carry the load.

Now included in the main wing section are 75-ft extruded 7178-T6 Alcoa Aluminum alloy panels which make possible fuel storage in nearly the whole in-spar area (out to the external underwing fuel tanks). The external fuel tanks provide still additional range.

By shaving some 10,000 lb from the previous model, the B-52G range is increased by about 6 per cent . . . a weight saving accomplished mainly by a redesign of the wing structure. Boeing engineers greatly increased interior fuel storage, replaced fuel bags with an integral wing configuration.

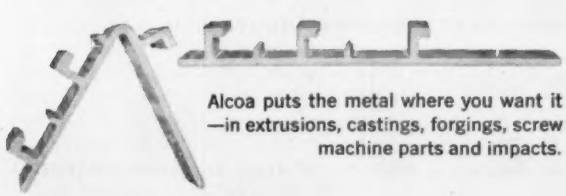
Alcoa Extrusions—in widths up to 35½ in.—are actually extruded for the B-52G in the "V" shape (pictured at right) on one of Alcoa's 14,000-ton extrusion presses. They are then cold rolled into the flattened cross section. The part is sent to Goodyear Aircraft Corporation, Litchfield Park, Ariz., for machining and assembling into a portion of the center wing section. Goodyear, in turn, ships the completed unit to Boeing Airplane Company, Wichita, Kan., for installation in the airplane. Extensive machining, riveting and assembly operations are eliminated by the use of these large extrusions—and the required strength is obtained with less weight than would be

HOW TO CARRY A "BIG STICK" 10,800 MILES!

necessary if the wide section were built up from smaller pieces.

Mammoth presses are only a part of the story. Complex auxiliary equipment, including a 120-ft-long stretcher (with 3,000,000-lb pulling force), roll straighteners and detwisters, enables Alcoa to extrude shapes that put the metal where it is wanted! With this extrusion equipment, Alcoa can produce closed-end containers up to 44 in. in diameter, stepped or other type extrusions up to 2,500 lb total weight, extrusions up to 39 in. in width, tubing of uniform or variable wall up to 19½ in. inside diameter. In addition to aircraft and other defense applications, large shapes extruded by Alcoa find uses in the electrical industry, pipelines, truck, bus, trailer, ship and architectural construction.

For more information, write Aluminum Company of America, 905-Y Alcoa Bldg., Pittsburgh 19, Pa. World-wide sales through Alcoa International, Inc., 230 Park Avenue, New York 17, N.Y.



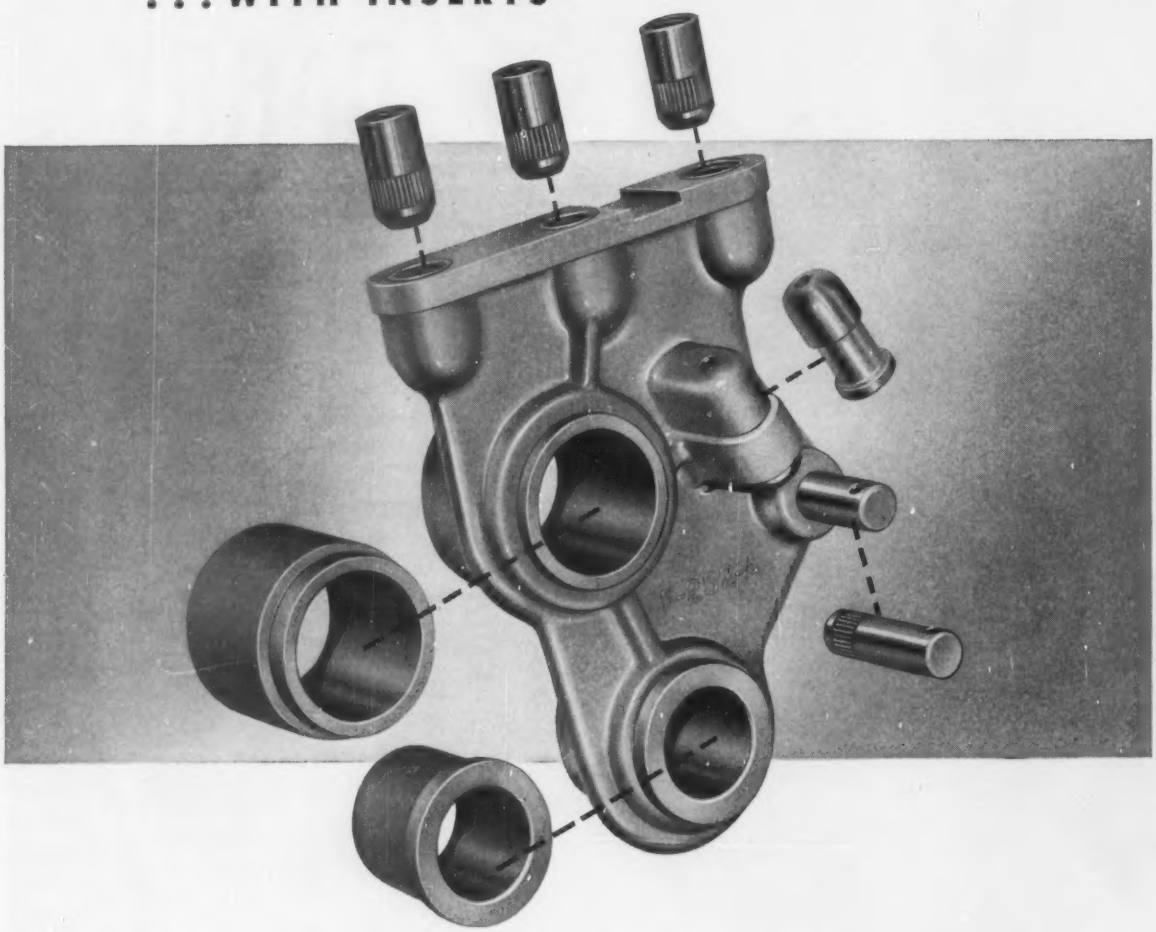
Alcoa puts the metal where you want it —in extrusions, castings, forgings, screw machine parts and impacts.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

DESIGNING TO ADVANTAGE

. . . WITH INSERTS



MADISON-KIPP ZINC AND ALUMINUM DIE CASTINGS

The aluminum instrument frame illustrated shows the use of seven functional iron and steel inserts. The part is lighter than when made of all iron, is more accurate, and the production potential from the Madison-Kipp die is adequate and sure.

You may be able to reduce costs or add value to your product with iron, steel or brass inserts in Madison-Kipp zinc or aluminum die castings.

Please address all inquiries to the home office at Madison, Wisconsin.

kipp

MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

RESEARCH PARTICIPANT

Skilled in Die Casting Mechanics • Experienced in Lubricating Engineering • Originators of Really High Speed Air Tools

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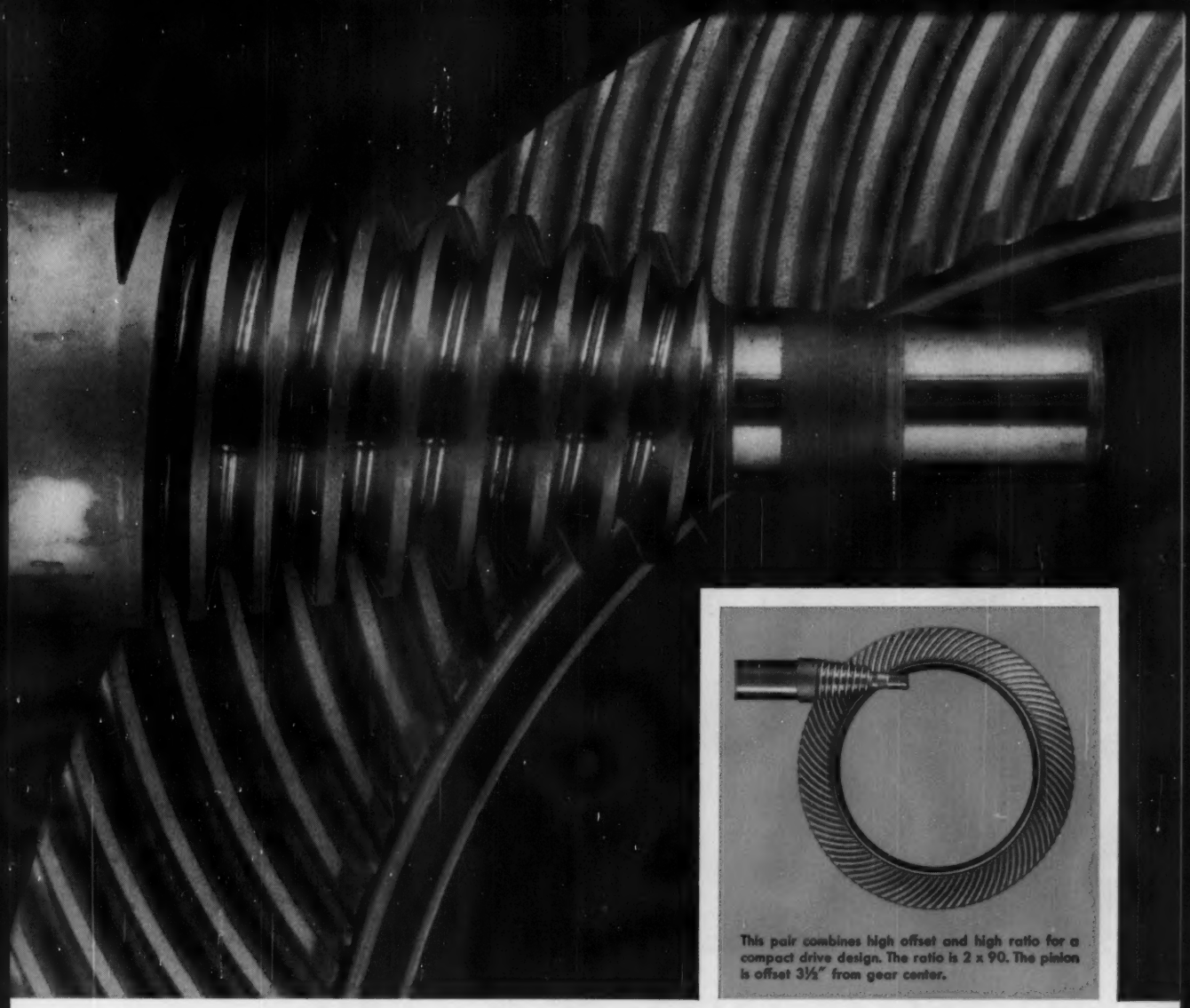

This pair combines high offset and high ratio for a compact drive design. The ratio is 2 x 90. The pinion is offset 3½" from gear center.

See how the teeth "wrap around" this high-reduction pinion

This is a high-ratio hypoid gear. In principle, it is not different from more conventional hypoids produced by the Gleason Works. *But . . .*

If you look closely at the pinion, you'll notice that the teeth tend to "wrap around" it. This design is extremely well suited for high reduction, strength and compact design.

The result is a conical (or sometimes cylindrical) pinion which permits *continuous tooth action—even with just one or two teeth!* Compared to corresponding bevel pinions, its diameter is greater for higher strength. An extended shank on cylindrical pinions makes *very rigid* straddle mountings practical.

You can design a *compact* unit, because high offset is possible! For high-offset *or* high-ratio pairs, the "wrap around" tooth design provides an extra measure of the smooth, quiet tooth action of hypoid gears.

High-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel gears and hypoids. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish.

High-ratio hypoids can be produced by the Gleason Works for ratios of 1:10 or 1:40 or even higher. They are finding a growing number of applications in such diverse fields as farm machinery, instrumentation and office equipment.

You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

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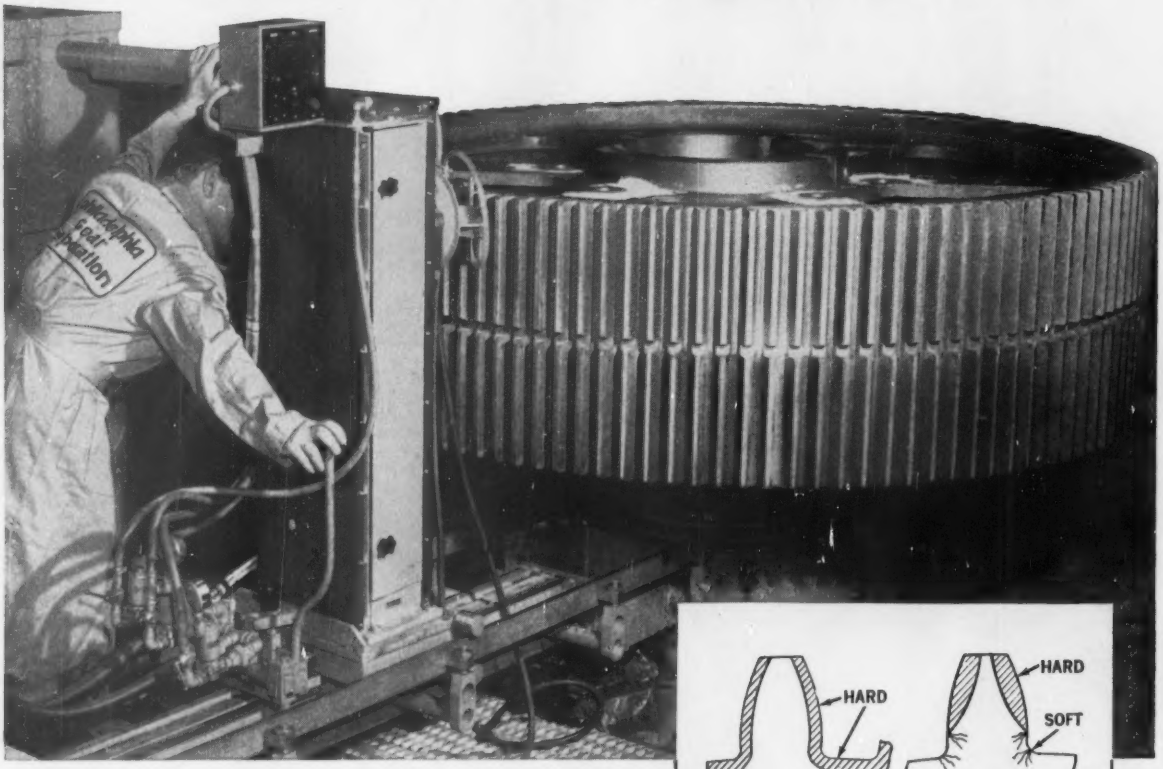
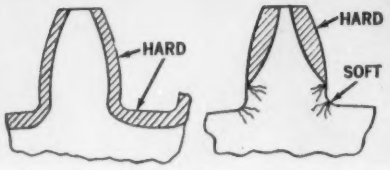
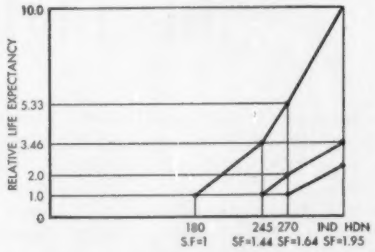
New Philadelphia induction hardening increases life of large gear drives . . .





New Philadelphia full contour induction hardening (left) provides a continuous hardened area from one tooth flank around the root and up the other flank without interruption. There are no points of stress. Typical heat treated gear (right) shows inadequate hardening of root of tooth, a point of major stress.



This chart shows the relationship between load and gear life. Note that the improved service factor of a gear set may be used to substantially increase gear life, rather than to increase the load.

HERE'S WHY: Full tooth contour induction hardening of large gears provides a uniformly hardened surface from one tooth flank around the root and up the other flank without interruption. Eliminates points of thermal stress concentration. And there is no distortion, a problem of heat treated gearing that requires subsequent grinding.

This new, advanced Philadelphia method permits radical reduction in sizing and/or increased load carrying capacities. And it can easily harden even the largest spur, helical and herringbone gearing up to 180 inches in diameter, 20 inches in face, and 3/4DP.

Learn more about this new method for increasing the service life of your gear drives. Write for your copy of Bulletin 100.

phillie gear® / **PHILADELPHIA GEAR CORPORATION**
King of Prussia (Suburban Philadelphia), Pennsylvania

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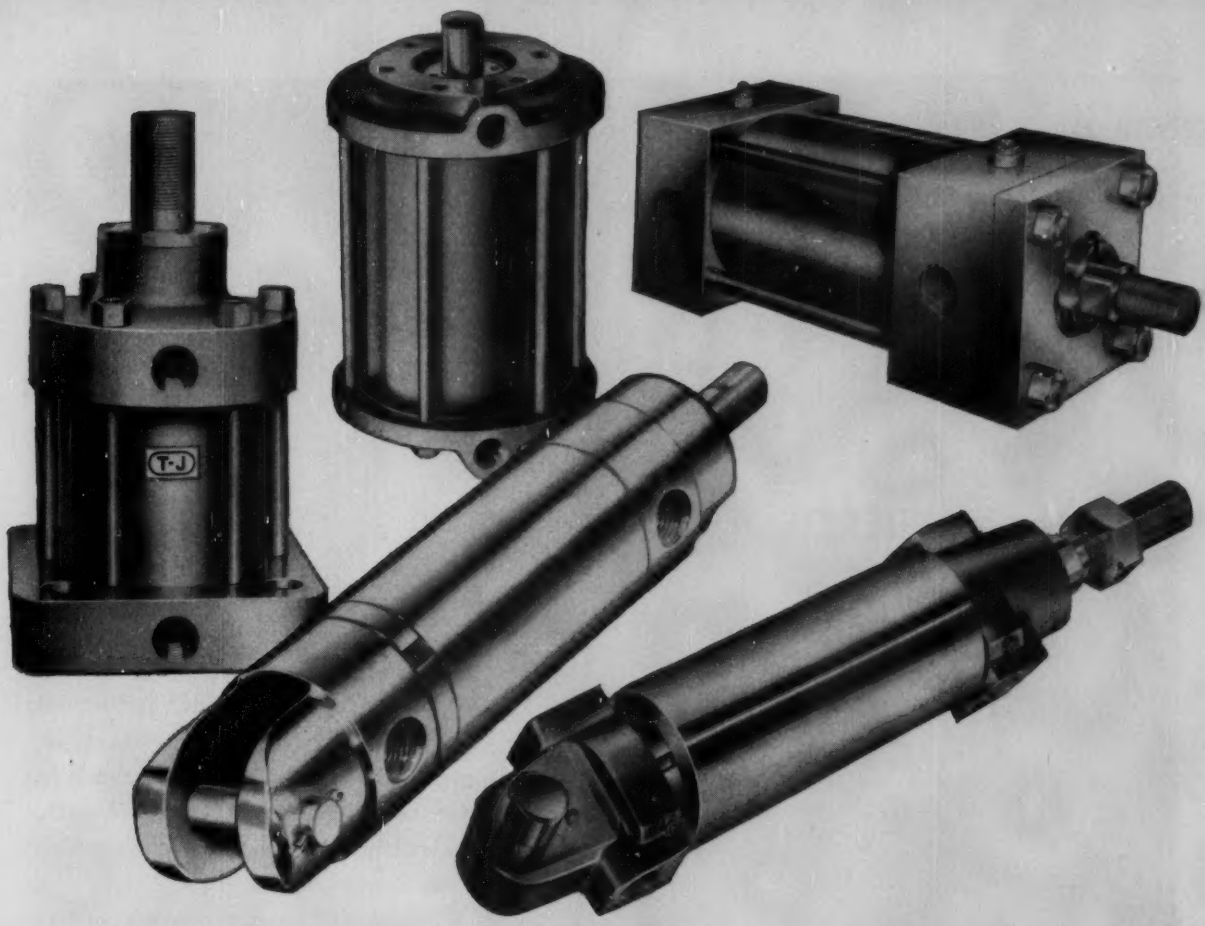


For Your Power Drive • Design • Application or Replacement Maintenance

There's a T-J CYLINDER

That Can Assure *Accurate Efficient Operation*

Only T-J's complete line can assure you a cylinder of either air or hydraulic application—with practically limitless design specifications for bore, stroke, pressure range and even delivery requirement. From the time-tested, standard tie-rod air and hydraulic, to the exclusive T-J Spacemaker, and including the recently introduced Squair Head, T-J cylinders give you more features for efficient, long-lasting operation. Write today!

Plus

THE ONLY COMPLETE ENGINEERING CATALOG LINE, TOO!

H-47 for standard tie-rod hydraulic cylinders.

SQ-1058-4 for the T-J Squair Head cylinder.

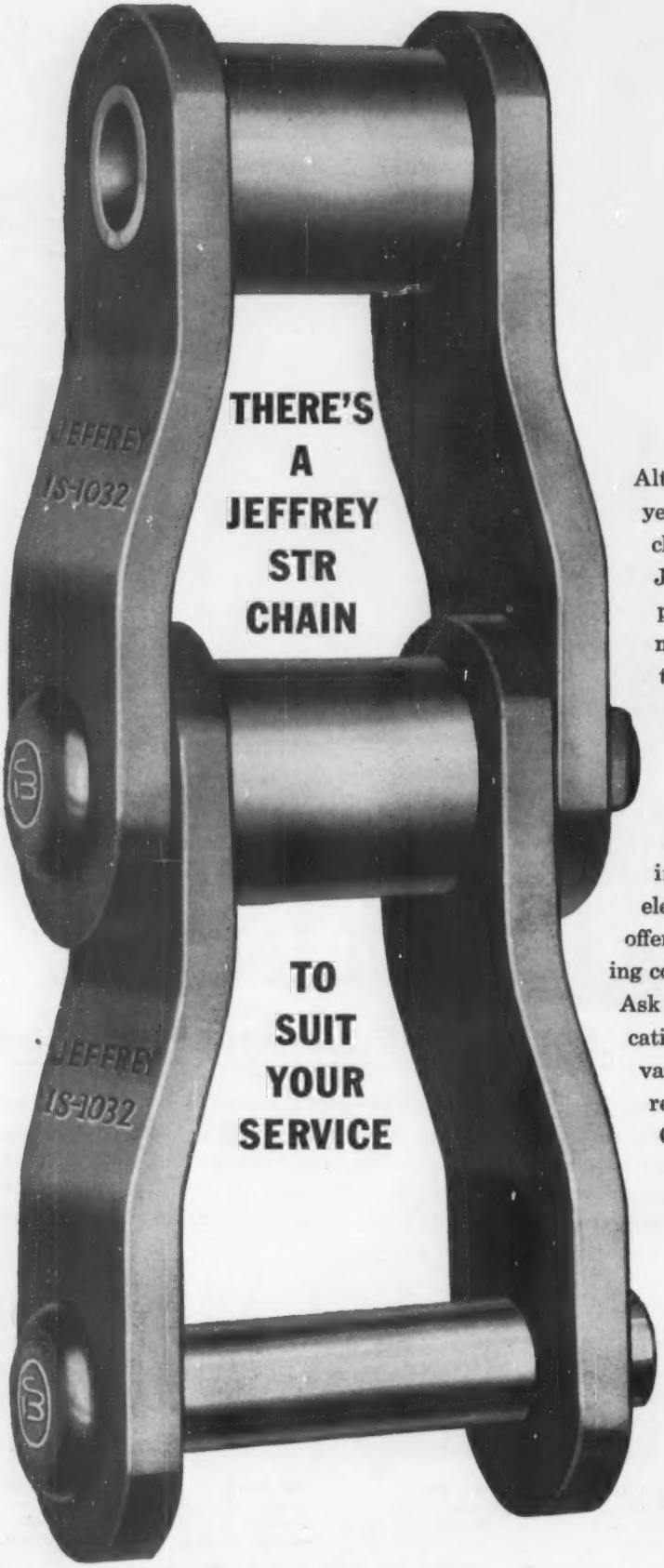
No. 54 for standard tie-rod air cylinders.

SM-58-3 for the incomparable Spacemaker cylinder.

HSM5-58-4 for the High-Pressure Hydraulic Spacemaker cylinder.

THE TOMKINS • JOHNSON CO. JACKSON, MICH.

CYLINDERS • MILLING CUTTERS • RIVETERS and CLINCHERS *Circle 465 on Page 19*



Although Jeffrey patented the principle years ago, STR (Steel Thimble Roller) chain has been constantly improved by Jeffrey to keep pace with industrial progress. Components are designed, materials selected, machined and heat treated to give maximum strength, shock resistance and wearability with minimum weight.

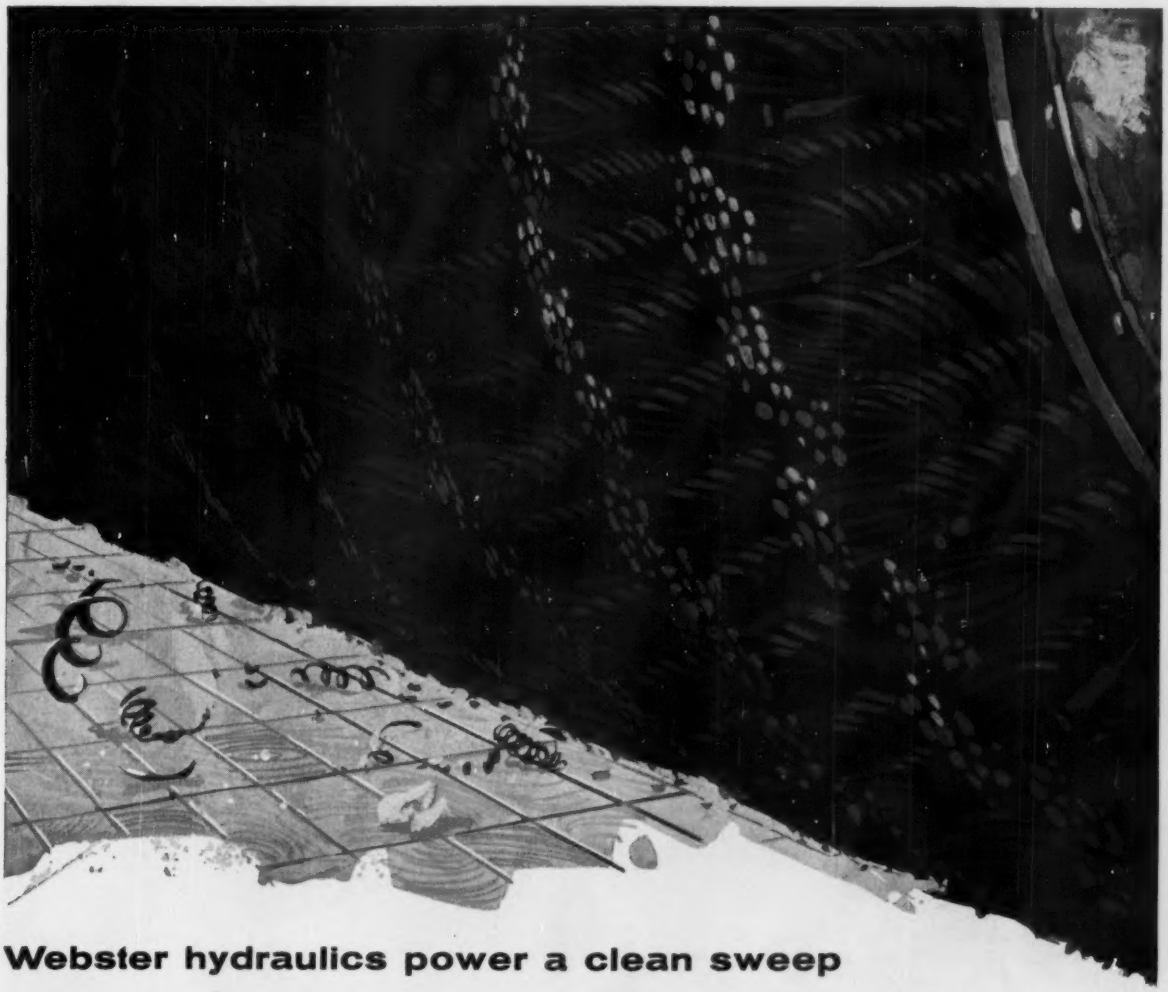
Jeffrey STR chain provides a positive yet flexible means of transmitting power for unit machinery and general industrial drives, and for heavy duty elevating and conveying service. Jeffrey offers four classes to meet various operating conditions.

Ask for engineering assistance on the application of STR chain to suit your needs. The various classes of STR chain are in stock, ready for immediate shipment to you. Chain also can be tailor-made to fit your particular requirements. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.

See your Jeffrey distributor for your chain requirements

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT... TRANSMISSION MACHINERY... CONTRACT MANUFACTURING



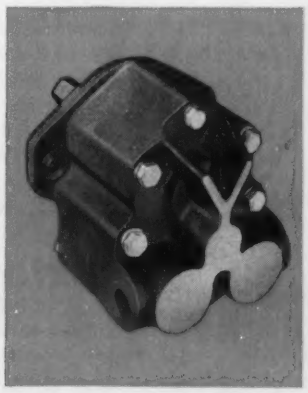
Webster hydraulics power a clean sweep

The business end of an industrial floor sweeper has its work cut out. Cleaning up grease-caked debris, metal chips, oil and grit is a tough demanding chore. It takes power — *versatile* power.

And a Webster HCS hydraulic motor supplies it for one of the most popular sweepers of this type! The HCS drives *both* the brush and the machine — maintains constant brush speed regardless of propelling speed. It has high torque with low power requirements (ideal for this application) and mounts in *any* position.

The HCS, typical of all Webster hydraulic motors and motor-pump combinations, operates at up to 1000 psi, with up to 206 torque pounds/inches per 100 psi (theoretical). It delivers up to 57 hp at speeds up to 2000 rpm.

Would a Webster hydraulic motor, pump or valve adapt to your product? Would it solve a power transmission problem? There's one way to find out — ask the advice of a specially trained Webster hydraulics engineer. There's no obligation. Write for action!



HCS HYDRAULIC MOTOR
Write for complete specifications and performance data.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

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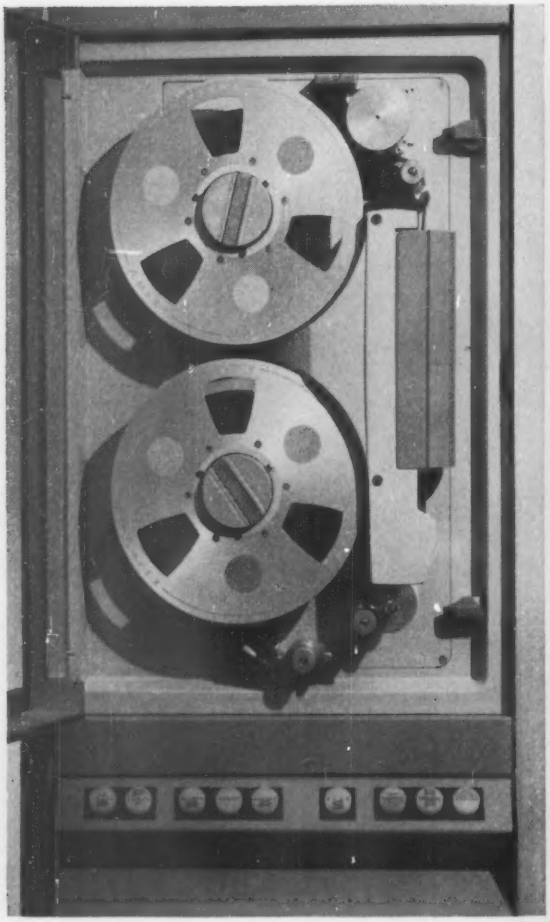

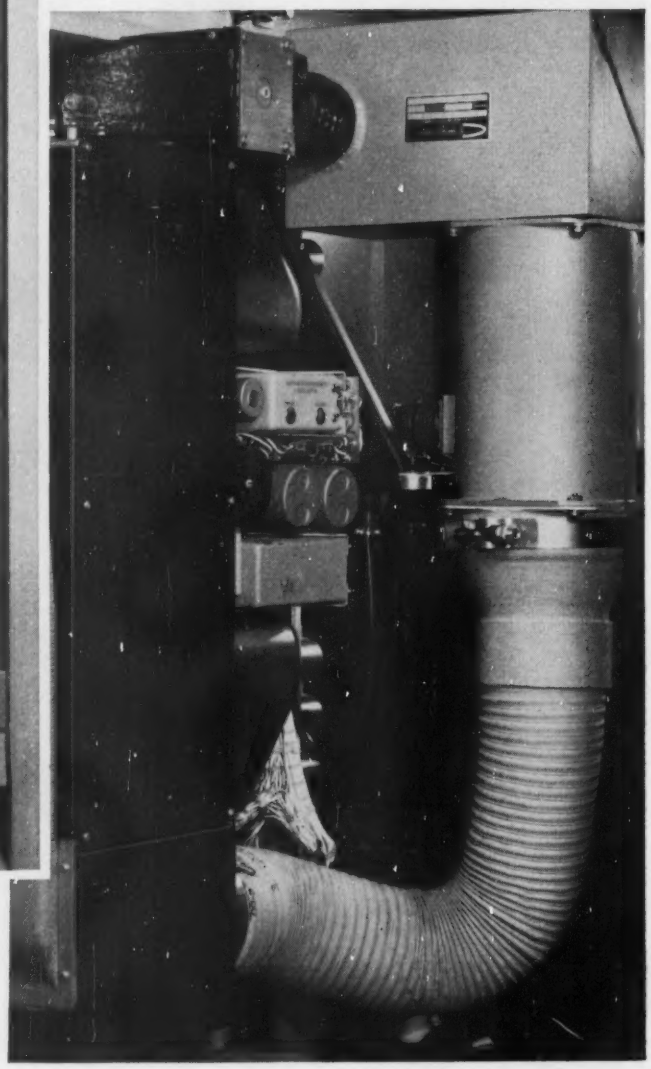

New Ampex FR-700 Tape Recorder, with tape transport closed (above), and opened (right). Flexible Tubing swings with the tape transport to provide constant ventilation.

How Flexible Tubing helps Ampex designers control tape recorder temperatures

In designing the new Ampex FR-700 Recorder, a big problem was how to keep internal temperatures between 40°C and 60°C. What's more, there was only limited space available for ventilation ducts!

Chosen by Ampex designers to handle this tough temperature-control job: a rugged nonmetallic duct with a wire helix — Flexible Tubing's "Flexflyte."

"Flexflyte" allows Ampex designers to carry cooling air anywhere there's available space. It's lightweight, easy to install, long-wearing. Offers great design flexibility!

If you work on any kind of original equipment where the handling of air, liquids or light solids is a design problem, there's a Flexible Tubing product for the job. You can choose coverings, coatings and sizes to fit your specifications.

Flexible Tubing is at work today on diesel engines, farm combines, vacuum cleaners and hundreds of other places. To find out how Flexible Tubing can help you, consult your Flexible Tubing regional sales engineer.

Flexible Tubing
CORPORATION
611 New Whitfield St., Guilford, Conn.
Anaheim (Los Angeles) • Hillside (Chicago)

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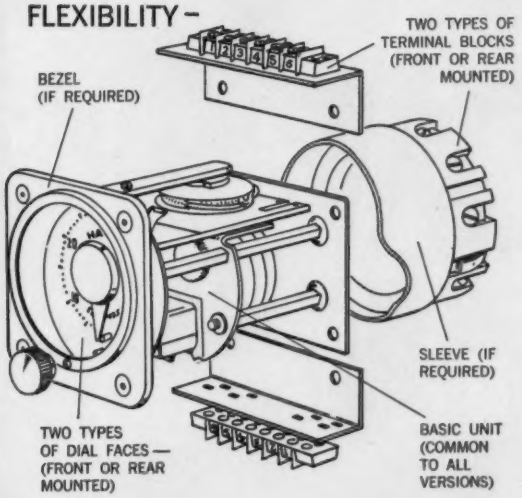
NEW External Clutch Reset ACROTIMER

FLEXIBILITY –


TWO TYPES OF TERMINAL BLOCKS (FRONT OR REAR MOUNTED)
BEZEL (IF REQUIRED)
SLEEVE (IF REQUIRED)
TWO TYPES OF DIAL FACES — (FRONT OR REAR MOUNTED)
BASIC UNIT (COMMON TO ALL VERSIONS)

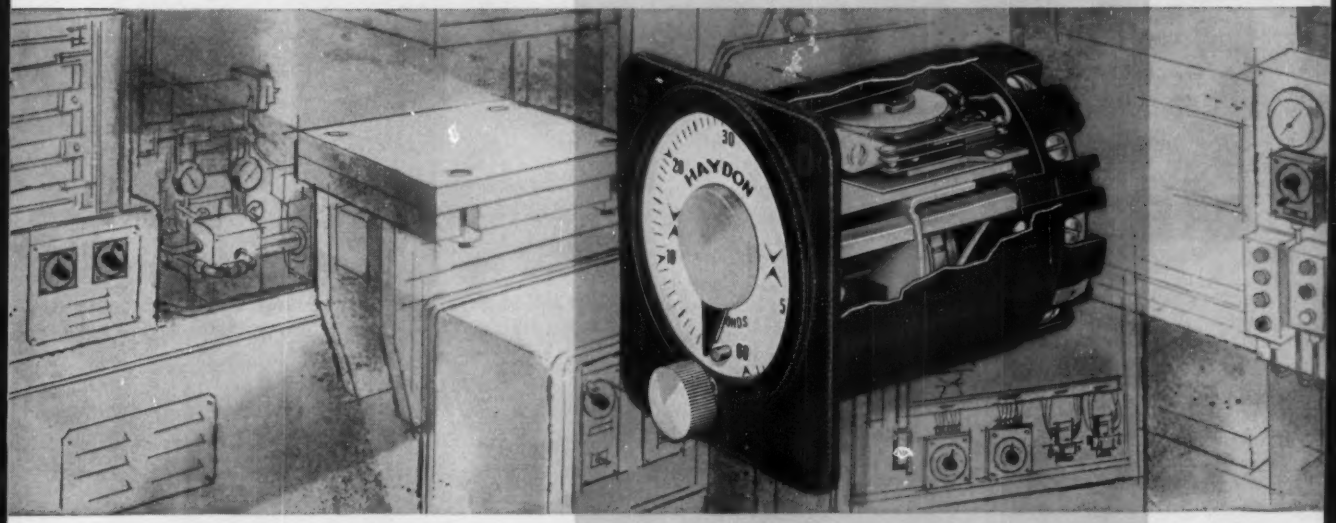
Provides time delay or interval timing, opening or closing one or more switches after an adjustable period of time — and, in addition, offers you these advantages.

EXCEPTIONAL VERSATILITY . . . results from modular construction concept. One basic unit plus easily assembled standard parts provides 12 different variations to meet a very wide range of physical and electrical requirements. Reduces cost, speeds deliveries.

LOWER COST . . . than other units of comparable capacity and quality, because of savings made possible by advanced design and modular construction.

SIMPLE CONSTRUCTION . . . with fewer moving parts. This means greater dependability and contributes to lower purchase price without sacrificing quality and performance.

COMPACT . . . ½" shorter than the next smallest competitive unit and 1" smaller than most competitive units.



Supplied for rear or panel mounting, the ACROTIMER line is designed for operation at 120 to 240 vac, 50 or 60 cycles. Adjustable time ranges from 6 seconds to 4 hours are available. For complete information on these timers, write today for your free copy of the new Haydon ACROTIMER Catalog.

HIGHER RATED LOAD SWITCHES . . . with your choice of one 15-amp or two 10-amp switches.

SPRING-TYPE CLUTCH . . . means negligible wear; longer life; and faster, more positive engagement.

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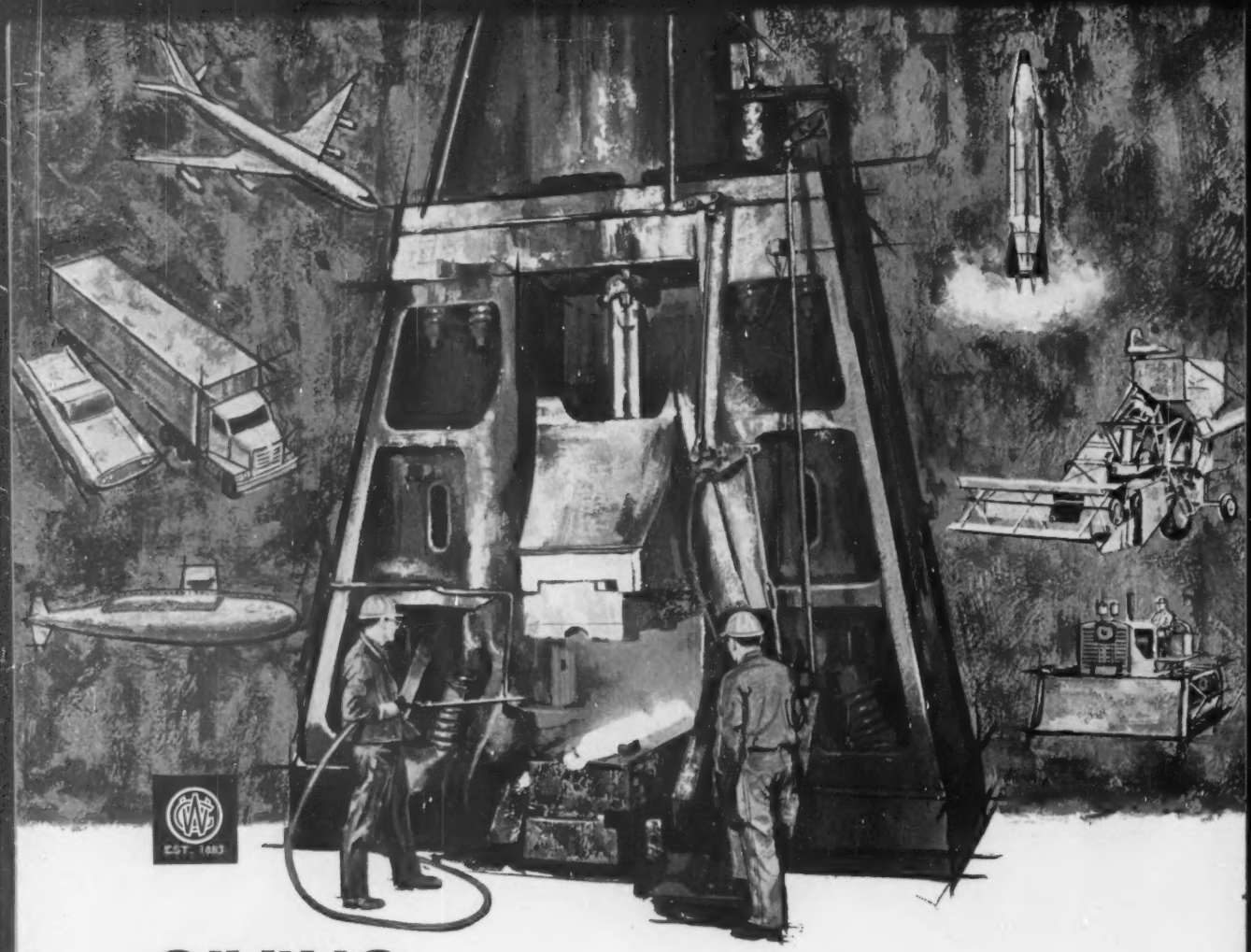
Circle 469 on Page 19

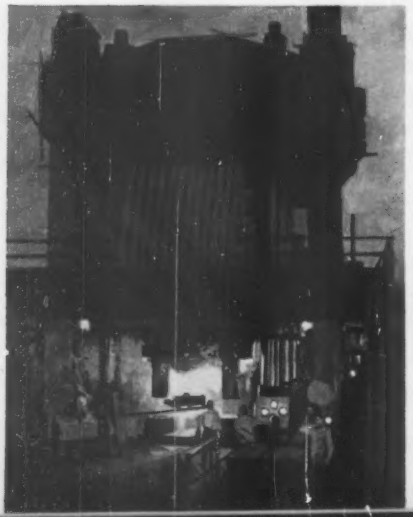


GIVING METAL NEW MUSCLE BY FORGING

. . . a specialty Wyman-Gordon knows best and is best equipped to perform for you

Specify "punishing service" in any environment—land, sea, air or space—and there is no substitute for a forging's endurance. Likewise, specify reliability in your supplier and there is no substitute for experience.

Here Wyman-Gordon has the outstanding record. Our background in hot working all forgeable materials covers more than three-quarters of a century. From it have come most of today's major advances—in forging techniques, metallurgical controls and development of facilities for extending size and complexity of forged parts. This accumulated know-how has done much to make Wyman-Gordon "forging headquarters" for an impressive list of industrial leaders.



Most likely our experience in saving weight, adding strength and reducing machining cost on countless other parts—can do as much for yours. To get expert appraisal, ask to have a forging engineer call while designs are still on the board.

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

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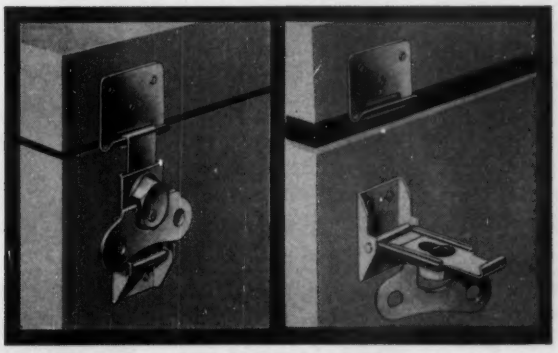
GRAFTON MASSACHUSETTS LOS ANGELES CALIFORNIA PALO ALTO CALIFORNIA FORT WORTH TEXAS

Circle 470 on Page 19

Zero cases, sealed pressure-tight by **LINK-LOCK**,

Simmons No. 3 LINK-LOCK fasteners are employed on these deep-drawn aluminum Zero transit cases. LINK-LOCK is available in three sizes, for light, medium, and heavy duty.



No. 2 LINK-LOCK. Half turn applies high closing pressure, counter-turn disengages for opening.

guard instruments against humidity, dust, atmospheric pressure changes

Delicate electronic and optical equipment is shipped long distances . . . handled again and again . . . and sometimes stored for long periods in transit cases manufactured by the Zero Manufacturing Company, Burbank, California.

The unique containers shown here are deep-drawn aluminum, seamless, with precision-fitting gasketed lids. They comply with rigid military specifications, insuring protection of contents against humidity, dust, and variations in pressure.

To effect the critically important pressure-tight seal, Zero specifies Simmons LINK-LOCK fasteners.

Here's why LINK-LOCK is ideal for use on precision-built military cases as well as on inexpensive commercial containers:

- Positive-locking without springs.
- Impact and drop resistant; not affected by arctic temperatures.
- Compact design—lies flat open or secured.
- Latch design can be varied to suit different applications.
- High preloading and high load-carrying capacity.

WRITE FOR CATALOG NO. 760

It contains specifications, drawings, details of LINK-LOCK and other Simmons Fasteners with unlimited money-saving applications.

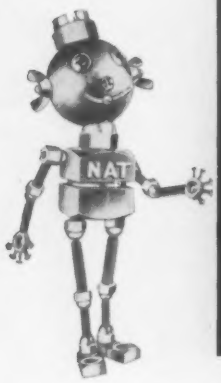
SIMMONS FASTENER CORPORATION

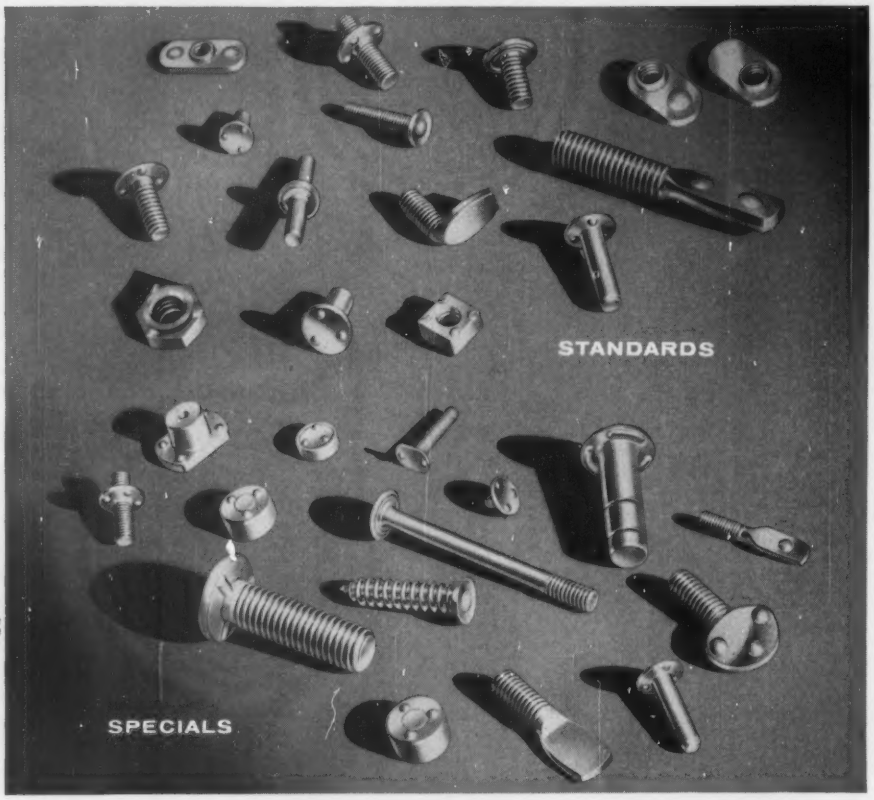
1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK • HINGE-LOCK

See our 8-page catalog in Sweet's Product Design File

NAT'S
quick facts
about
Fasteners...





Welding Fasteners...

the little things that make a big difference

Welding Fasteners put threads into the most unlikely places, and make light of the weightiest assembly problems.

Where hands and wrenches can't get in, for instance, or where material dimensions or contours make it next to impossible to use regular fastening methods, Weld Nuts or Weld Screws neatly side-step the difficulties . . . and make assembly simple, fast and foolproof.

We could go on and tell you more about Welding Fastener advantages . . . in improving product design and quality, increasing production efficiency, and cutting costs . . . and we'll be very glad to, if you like.

Right now, though, we'd just like to say that when you need certain standard Weld Nuts or Weld Screws, and you want to be sure they're designed right and made right . . . that's where we come in. We *know* Welding Fasteners, and we *stock* many of the most commonly used.*

We might just mention, too, that we happen to be particularly adept at developing Special Fasteners for welding. They can often be designed to do a better job and save money for you. Ask us about your applications.

*Standard types and sizes are illustrated and listed in National's booklet on Welding Fasteners. Write for your copy.

National PRODUCTS

The National Screw & Mfg. Company · Cleveland 4, Ohio

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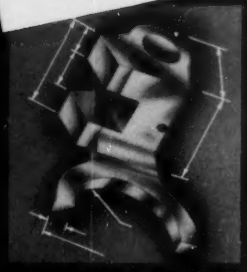
BUNTING® BEARINGS

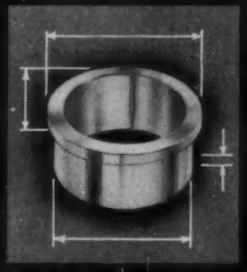
engineering for **both** cost and mechanical requirements in the bearing field . . .

Bunting can help you identify and procure the bearing or part that will do your job at the lowest possible cost. Often a re-examination of the actual mechanical needs of a bearing application reveals an opportunity to save money in design. Another saving is almost invariably achieved by considering ALL the new bearing materials which Bunting makes available to you today. Let Bunting help you engineer your bearing application in the light of modern availabilities. Send in your blueprints or ask for engineering counsel.

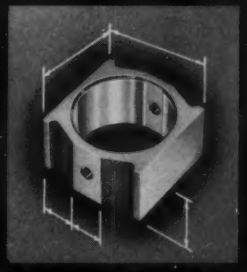
...case in point*



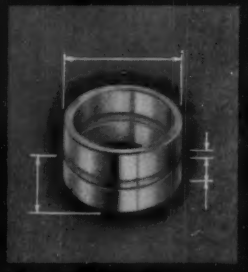
*Clearly evident is the economy in the production of this shifter fork by Bunting Powder Metallurgy. The elimination of machine work effects striking cost reduction.



*This cylinder gland bearing made of Bunting Bearing Aluminum is an example of how to save weight and money on the cost of large, thick-wall bearings and parts.



*This cast bronze cam block, made to unusually close limits with very fine finish, is absolutely round and true to size with cost at a feasible figure.



*Solid cast aluminum gear bearing to replace roller bearing for longer life and lower cost.

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NO. 158 • GENERAL CATALOG—Complete listings of Cast Bronze and Sintered Bronze Stock Bearings and Bars and Bunting Bearing Aluminum Bars. Pocket size edition.

NO. 1 • • • ENGINEERING HANDBOOK OF POWDER METALLURGY—A comprehensive technical treatment of engineering and manufacturing of sintered metals, bearings and parts.

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ONE MAN ONE TRADE ONE TOOL

...your production line back in operation in

30 SECONDS

(if it's a Hunt PDQ Air Control Valve)

☑ **accessibility** ☑ **simplicity** ☑ **speed and capacity** ☑ **price and quality**

Circle 474 on Page 19

No bulletin can do it justice... have the Hunt man call. Write to:

HUNT HUNT VALVE COMPANY DIVISION OF IBEC SALEM, OHIO

Quick-As-Wink AIR & HYDRAULIC CONTROL VALVES

MACHINE DESIGN

November 24, 1960

Worry Warts Anonymous

EVERYONE has problems—either their own or those they acquire from someone else. And the viewpoint most people instinctively take is, "I'll worry about my problems, and you worry about yours."

Engineering is a type of work that can foster this self-sufficient attitude. Engineering is often an individual activity. Ideas are born and problems solved in the cold isolation of one's own brain. And most engineering analysis requires the personal application of specialized technical knowledge.

A designer can't afford to fall into this comfortable, well-insulated rut —even if he'd like to. Granted, much design activity involves individual effort. But we might say that at least half of all design work is organized worrying about other people's problems.

First comes the purchaser of the product—the consumer, the armed services, other companies. Then there are other departments and people concerned with handling the product—production and inspection departments, outside suppliers, outside service and repair organizations. Every part or assembly must be designed to take into account the needs of all these people.

There are many ways of coping with the situation. For instance, a standards organization within a company can enforce use of acceptable components and materials. Production design groups can make sure that a part can be manufactured before it is ever released for production. And the design review system suggested by D. P. Simonton in his article starting on the next page can be invaluable in anticipating everyone's problems before they grow to monstrous proportions.

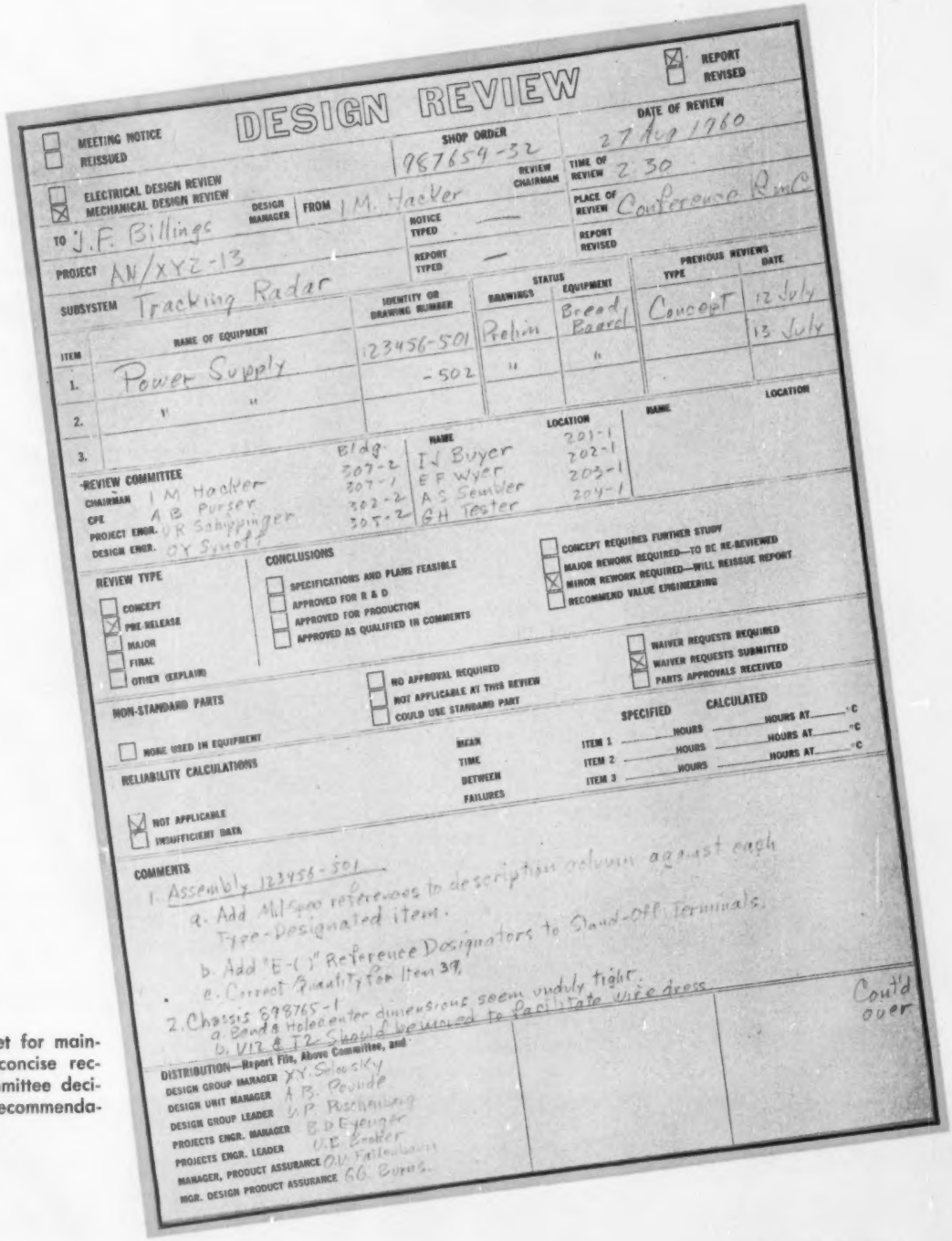
But the prime responsibility still rests with the individual design engineer. If he takes an ivory tower viewpoint, everyone else suffers—or he gets fired. And only when all possible questions are answered is the design 100 per cent satisfactory.

Even though this perfection is probably an impossible goal, we try to achieve it in design. Often, all we need is a constant reminder. So how about joining a new (and fictitious) organization, Worry Warts Anonymous. No dues, no membership fees, no bylaws. Just concentrated attention to the half of design work that's most likely to be neglected—how to solve the other fellow's problems.

Robert L. Stedfeld

ASSOCIATE MANAGING EDITOR

THE DESIGN



DESIGN REVIEW

☐ MEETING NOTICE REISSUED
☒ REPORT REVISED
☐ ELECTRICAL DESIGN REVIEW
☒ MECHANICAL DESIGN REVIEW
SHOP ORDER 987659-52
DATE OF REVIEW 27 Aug 1960
TO J.F. Billings — DESIGN MANAGER — FROM I.M. Hacker — REVIEW CHAIRMAN
TIME OF REVIEW 2:30
PLACE OF REVIEW Conference Rm C
NOTICE TYPED —
REPORT TYPED —
REPORT REVISED
PROJECT AN/XYZ-13
SUBSYSTEM Tracking Radar

ITEM	NAME OF EQUIPMENT	IDENTITY OR DRAWING NUMBER	STATUS: DRAWINGS	STATUS: EQUIPMENT	PREVIOUS REVIEWS: TYPE	PREVIOUS REVIEWS: DATE
1.	Power Supply	123456-501	Prelim	Bread Board	Concept	12 July
2.	" "	-502	"	"		13 July
3.						

REVIEW COMMITTEE

	NAME	LOCATION
CHAIRMAN	I M Hacker	Bldg. 307-2
CPE	A B Purser	307-1
PROJECT ENGR.	U R Schippinger	302-2
DESIGN ENGR.	O K Synott	305-2
	I J Buyer	201-1
	E F Wyer	202-1
	A S Sembler	203-1
	G H Tester	204-1

NAME — LOCATION

REVIEW TYPE
☐ CONCEPT
☒ PRE-RELEASE
☐ MAJOR
☐ FINAL
☐ OTHER (EXPLAIN)

CONCLUSIONS
☐ SPECIFICATIONS AND PLANS FEASIBLE
☐ APPROVED FOR R & D
☐ APPROVED FOR PRODUCTION
☐ APPROVED AS QUALIFIED IN COMMENTS
☐ CONCEPT REQUIRES FURTHER STUDY
☐ MAJOR REWORK REQUIRED—TO BE RE-REVIEWED
☒ MINOR REWORK REQUIRED—WILL REISSUE REPORT
☐ RECOMMEND VALUE ENGINEERING

NON-STANDARD PARTS
☐ NONE USED IN EQUIPMENT
☐ NO APPROVAL REQUIRED
☐ NOT APPLICABLE AT THIS REVIEW
☐ COULD USE STANDARD PART
☐ WAIVER REQUESTS REQUIRED
☒ WAIVER REQUESTS SUBMITTED
☐ PARTS APPROVALS RECEIVED

RELIABILITY CALCULATIONS
☒ NOT APPLICABLE
☐ INSUFFICIENT DATA

MEAN TIME BETWEEN FAILURES		SPECIFIED	CALCULATED
	ITEM 1	____ HOURS	____ HOURS AT ____ °C
	ITEM 2	____ HOURS	____ HOURS AT ____ °C
	ITEM 3	____ HOURS	____ HOURS AT ____ °C

COMMENTS
1. Assembly 123456-501
   a. Add MilSpec references to description column against each Type-designated item.
   b. Add "E-( )" Reference Designators to Stand-Off Terminals.
   c. Correct Quantity for Item 39.
2. Chassis 698765-1
   a. Bend & Hole center dimensions seem unduly tight.
   b. V12 & T2 Should be moved to facilitate wire dress.

Could over

DISTRIBUTION—Report File, Above Committee, and:
DESIGN GROUP MANAGER X.Y. Silovsky
DESIGN UNIT MANAGER A.B. Peoride
DESIGN GROUP LEADER U.P. Paschanberg
PROJECTS ENGR. MANAGER B.D. Eyeguer
PROJECTS ENGR. LEADER U.E. Booker
MANAGER, PRODUCT ASSURANCE O.V. Fatterbaum
MGR. DESIGN PRODUCT ASSURANCE G.G. Burns

Report sheet for maintaining a concise record of committee decisions and recommendations.

REVIEW PROGRAM

D. P. SIMONTON
Manager, Design Support Services
West Coast Missile & Surface Radar Div.
Radio Corp. of America
Van Nuys, Calif.

WANTED:

A practical method of appraising a design at critical stages. One way to cope with this problem is the design review. It offers a method of evaluating a proposal, suggesting improvements, and incorporating changes while the design is still fluid. At the same time, it provides direct communication among design groups, and liaison with production.

THE design review program consists basically of a number of meetings called at certain points in the life cycle of a design, from conception to production. At these meetings, attended by a carefully selected group of men involved in some aspect of the design, viewpoints are exchanged, errors are ferreted out, and recommendations are made concerning changes.

The design review is, in effect, a checklist through which the design is evaluated at various stages. Every effort is made to provide an exchange of information among various departments of engineering and manufacturing at these reviews. If, for example, a heat-dissipation problem is uncovered at an electrical review, it is not concealed beneath the electrical bushel, but is passed on to the mechanical design engineer. Thus, the "feedback" problem is almost completely eliminated.

This article outlines a representative mechanical design review procedure. The complete review process may also include electrical and wiring reviews, Fig. 1, but these are handled in the same manner as the mechanical review. Although this procedure has been formulated for use by a large electronics manufacturer, it can be adapted to any type of design operation.

Review Stages

The concept review is held as soon as there is a concept to review. This may sound silly, but it is surprising how quickly a design in an engineer's mind ceases to be a concept and becomes concrete. The questions asked at a concept review should shake the design down to its foundations. The right time for the mechanical concept review is as soon as the drafting layout or schematic is reasonably firm.

Some of the factors to be considered at this review are:

Adherence to Specifications: This includes specifications at all levels—project, company, and military.

Reliability: This is generally more easily measured quantitatively at the electrical review, but is nonetheless important in the mechanical review.

Safety of Personnel: Not only high-voltage killers, but

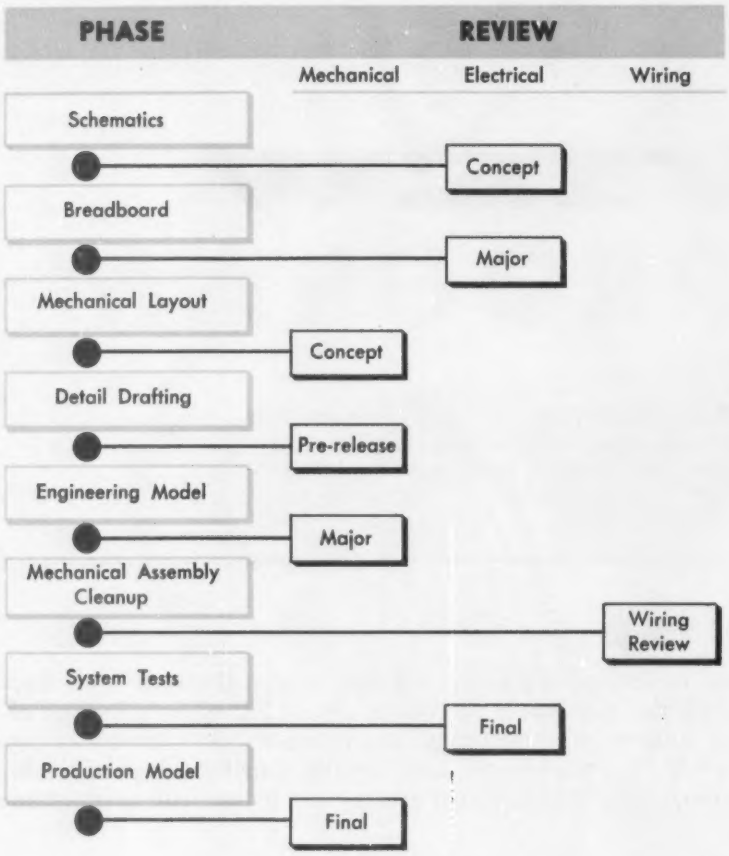


Fig. 1—Design review phase sequence, indicating at what point each review takes place.

also knuckle-nibbling burrs and sharp corners must be eliminated.

Appearance and Human-Engineering Factors: Few companies can afford to put out a product which looks shoddy and ill proportioned, and which does not "fit" people.

Economy of Manufacture: Value engineering factors are becoming more vital. For example, producing an expensive design and then changing it to something more economical may provide impressive "savings" on a monthly report; however, the design review can assure design economy from the outset.

Environmental Adequacy: The equipment should be designed to survive dust, heat, vibration, corrosion, fungus, shipping, and other natural and human outrages to which it will be subject.

Maintainability: The maintenance philosophy of each assembly, as well as that of the whole system, must be known and applied from the outset.

Compatibility: As systems grow in size and complexity, the problem of fitting the components together also grows.

The prerelease review is held just prior to the time when the drawings are to be signed off for release into the procurement cycle. All the factors mentioned for the concept review apply once again. In addition, design data and minutes of previous reviews should be available for reference. Details such as finishes, fits, tolerances, fastening hardware, fabrication and assembly notes, reference and function designations, and test instructions should be scrutinized.

A major review may be called following the completion of the engineering model assembly, testing, or subsystem testing to look at a combination of items previously reviewed separately. Items to be stressed at this time are design changes, new part requirements, and general anticipation of assembly and field problems arising from the initial bringing together of the system elements. Normally, a major review is required only if design changes have occurred since prior reviews.

The final review may be called following production release if there are unforeseen increases in quantity, unusual feedback from the field, important late changes in specifications, etc.

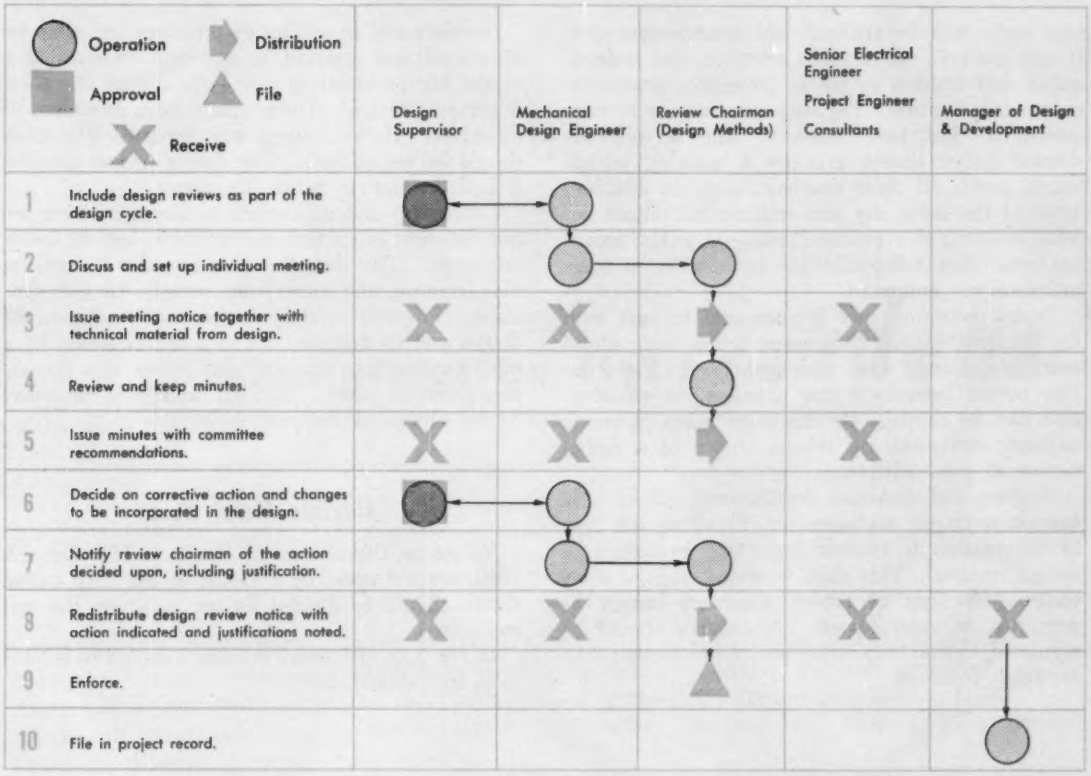

Operation
Distribution
Approval
File
Receive
Design Supervisor
Mechanical Design Engineer
Review Chairman (Design Methods)
Senior Electrical Engineer
Project Engineer
Consultants
Manager of Design & Development
1 Include design reviews as part of the design cycle.
2 Discuss and set up individual meeting.
3 Issue meeting notice together with technical material from design.
4 Review and keep minutes.
5 Issue minutes with committee recommendations.
6 Decide on corrective action and changes to be incorporated in the design.
7 Notify review chairman of the action decided upon, including justification.
8 Redistribute design review notice with action indicated and justifications noted.
9 Enforce.
10 File in project record.

Fig. 2—Duties of committee members.

A miscellaneous or **electromechanical review** may be called at any stage in the program, even after release, to resolve problems arising from design changes. The purpose is to gain flexibility within the design review structure, and thus assure coverage of any design problem which can profit by the surveillance of senior personnel.

Committee Structure

The Design Methods group, a small group of senior engineers which operates between design and project management, is usually directly responsible for making the design review program work.

With one of its members acting as chairman and moderator, the design review committee includes:

Design Engineer.
Design Engineering Supervisor.
Mechanical Co-ordinator for Design.
Senior Electrical Design Engineer.
Project Engineer.
Consultants.

More than one of these various design review functions might be filled by one individual. The attendance must be tailored to provide adequate coverage, but too many people can kill the effectiveness of a review.

In general, management should not take a strong part in the meetings. Such action tends to stifle participation by the engineers themselves. The uninhibited "opening up" by individual participants contributes most to a good review.

Usually, the review committee is given free rein to recommend any change which it would like to see in the design, without regard to the effect on schedules. The chairman then publishes the design review report, after which design engineering decides which changes will be incorporated. Thus, there is a valuable record of ideas for future reference, yet there are no unilaterally invoked changes which might delay deliveries. Fig. 2 shows a flow diagram of this procedure.

Advantages

Immediate advantages of the design review in terms of design excellence, use of standards, improved value, etc., are obvious. However, there are other advantages which are not as apparent, but nonetheless valuable.

Training junior engineers is always best done through the use of case studies rather than by exposure to vague generalities. But even the best

case study may be artificial and nonrepresentative. It may not hold the trainee's attention, and is dead-ended and fruitless as far as immediate productive output is concerned. Training must usually be considered a "lost time" activity. But a well-conducted design review provides a training vehicle which avoids all these disadvantages. In addition, some of the more shy and retiring individuals get what amounts to a practical course in public speaking, and their self-confidence and ability to communicate are enhanced.

Design personnel can be measured in part with the information that the review brings out. However, this must be done with great care. If the design review becomes a star chamber, its effectiveness can be ruined. By the same token, a young engineer can make his talents known in a design review to good advantage.

Progress and technical developments are of vital interest to project management. Providing this type of information is another important byproduct of design reviews. This does, however, require some control. Swarms of project engineers cannot be permitted in every review. Attendance should be regulated so that only those people are present who are really involved.

Interface and co-ordination problems can often be discovered and resolved at a design review. One of the big problems in any large design operation is communication. There should be a minimum of directives. Rather, direct working-level discussion should be encouraged. The design review provides a built-in way to bring this about.

Objectivity and willingness to accept criticism are not the most prominent characteristics among junior engineers. The design review provides a comfortable, routine, and inescapable remedy for this situation. Properly conducted, the review exposes the design and its designer, not to a brainwashing by a management "big brother," but rather to a sympathetic jury of peers. This atmosphere is important to the success of the program.

Flexible Metal Hose

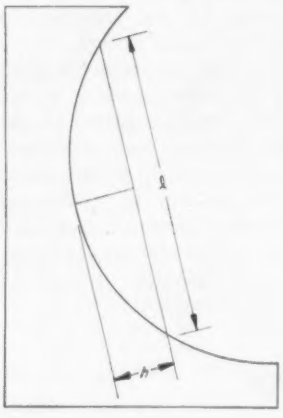
Values on the abscissa of Fig. 1, p. 196, Oct. 13, 1960, are too great by a factor of ten. All values shown should be divided by ten to obtain the correct values.

In Fig. 3, p. 197, curve number 3 should be labeled as $\frac{5}{8}$ in. nominal size.

Tips and Techniques

Finding Radius of a Circle

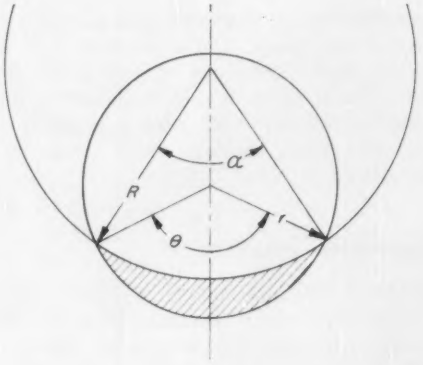
When the location of a circle's center is unknown, the radius can be found by this simple procedure:



1. Using any convenient scale, measure a chord length, l.
2. At the center of chord l, measure the distance h, perpendicular to the chord.
3. Unknown radius r is then computed as:

$$r = \frac{(l/2)^2 + h^2}{2h}$$

—Hwachii Lien, *Philadelphia, Pa.*



Area of Crescent

The area of a crescent formed by two intersecting circles can be calculated by the equation:

$$\text{Area} = \frac{r^2}{2}(\theta - \sin\theta) - \frac{R^2}{2}(\alpha - \sin\alpha)$$

where angles α and θ are in radians; R = radius of large circle; r = radius of small circle.—F. Murray, *Detroit, Mich.*

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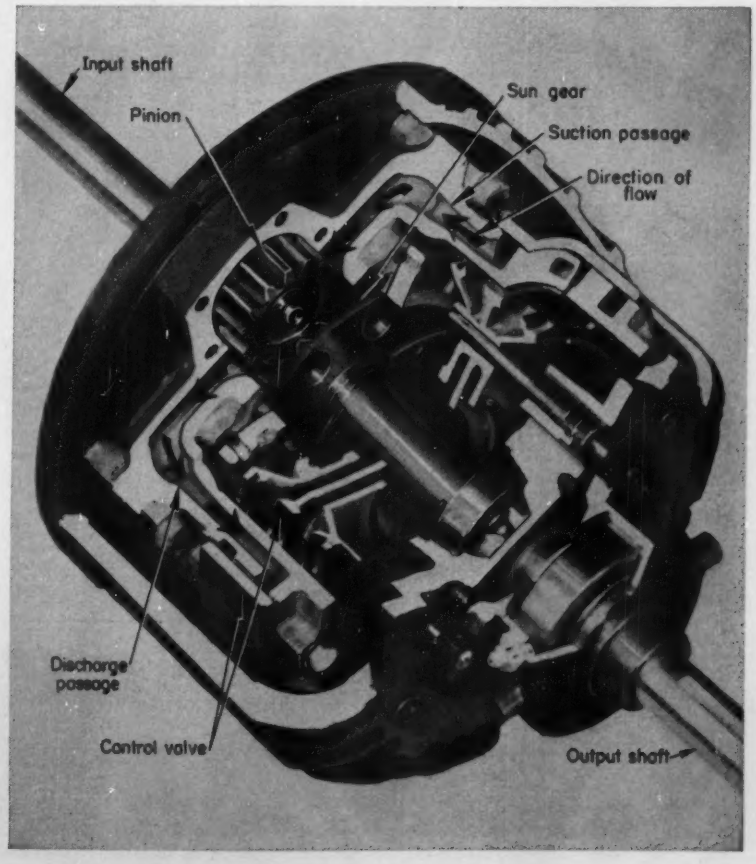
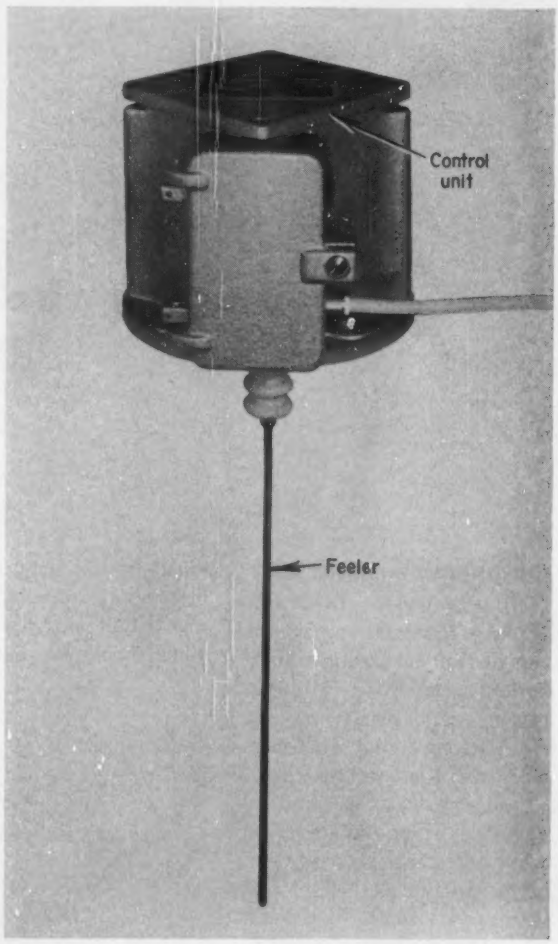
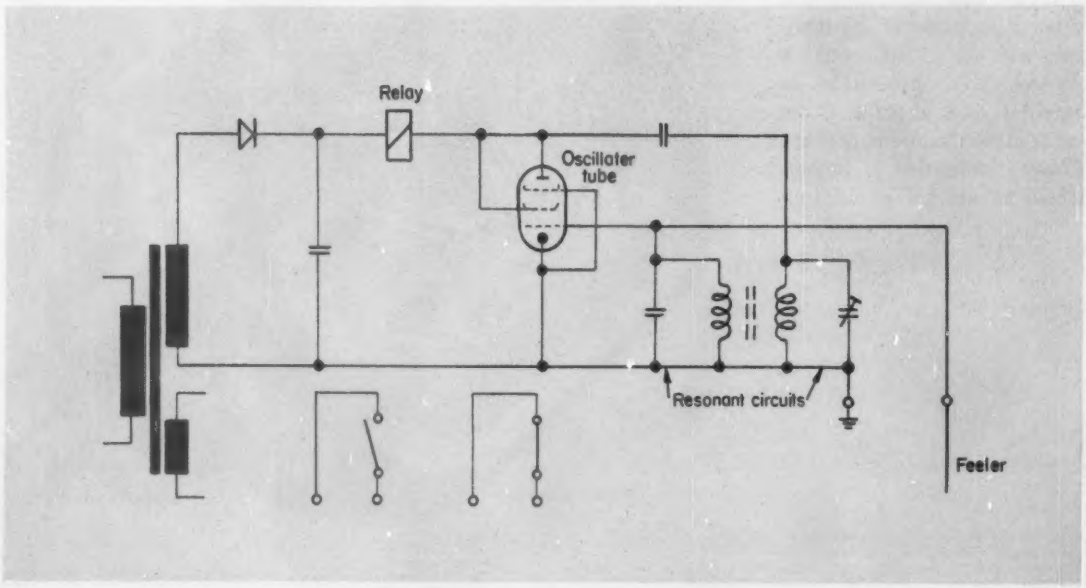
scanning the field for *ideas*

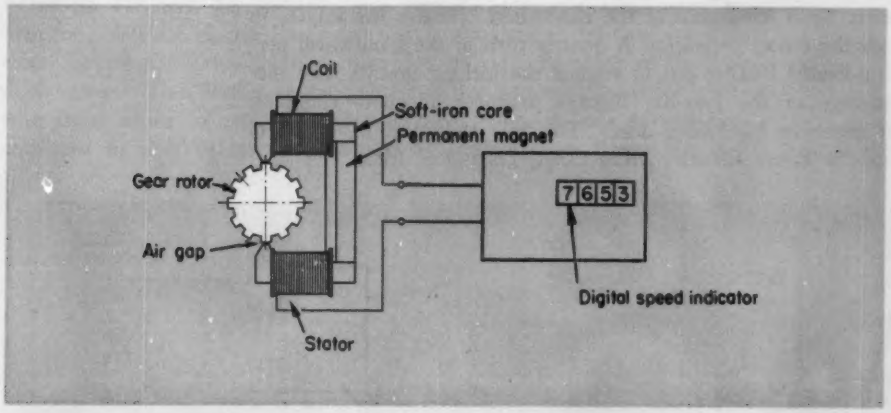
Oil-pumping planetary gears permit valves to control output torque and speed from zero to full engagement in a stepless-speed drive. Multiple planet gears, carried by the input-driven pump housing, react with the output-connected sun gear to produce a pumping action whenever a speed difference exists between input and output shafts. The housing is partially filled with oil. During operation, centrifugal force distributes oil around periphery of the housing, with air in the center. A control valve, operated by an external yoke, supplies either oil or air to the pumping gears. Power transmitted is proportional to amount of oil supplied. At full flow, the outlet passages are also blocked, locking the pinions to sun gear. Thus, the output shaft is solidly connected to the input shaft. Coupling principle employed in drive unit developed by Hydraulics Inc., Parsons, Kans.



Oscillator detuning provides indication of material presence in a depth gage. An adjustable-depth feeler is connected to one resonant circuit. When the material level approaches the feeler, the resulting change in capacitance detunes a measuring circuit. Current increase in the oscillator actuates a relay. When the material level falls, oscillation resumes, and the relay is opened. Principle employed in depth gage developed by Claudius Peters AG, Hamburg, Germany.

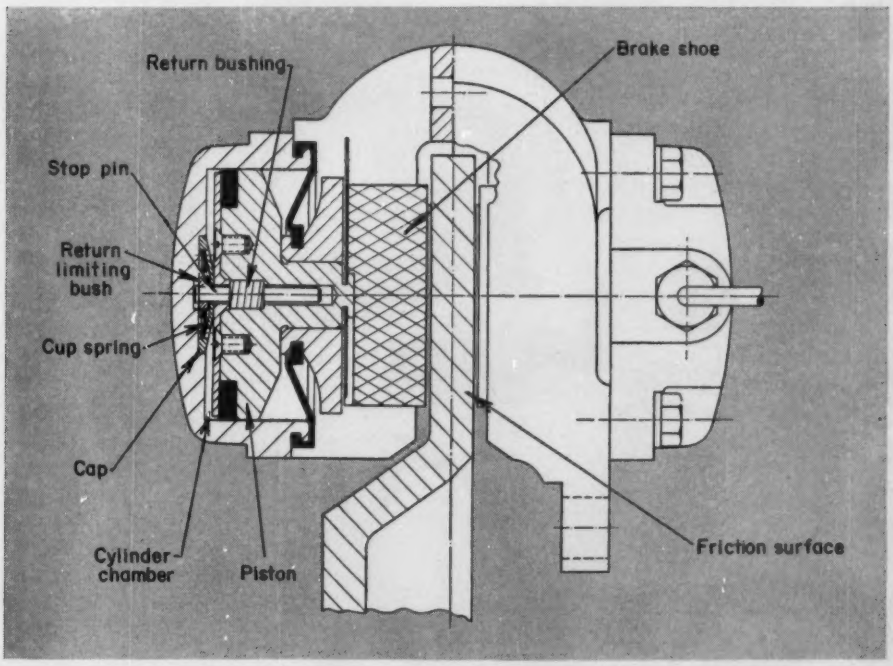






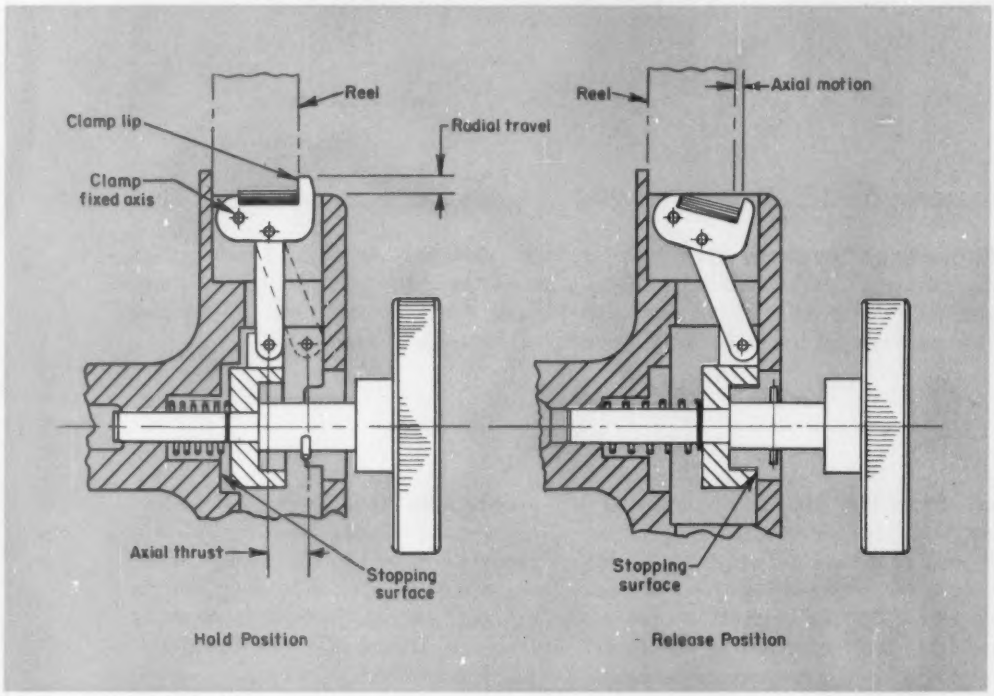
Magnetized gear teeth provide readout pulses for a digital tachometer. The pulse generator can be arranged to use the teeth of an existing gear or those of a separate rotor driven by a tachometer generator and a synchronous motor. Measuring principle developed by SA Rochar Electronique, Montrouge, France.

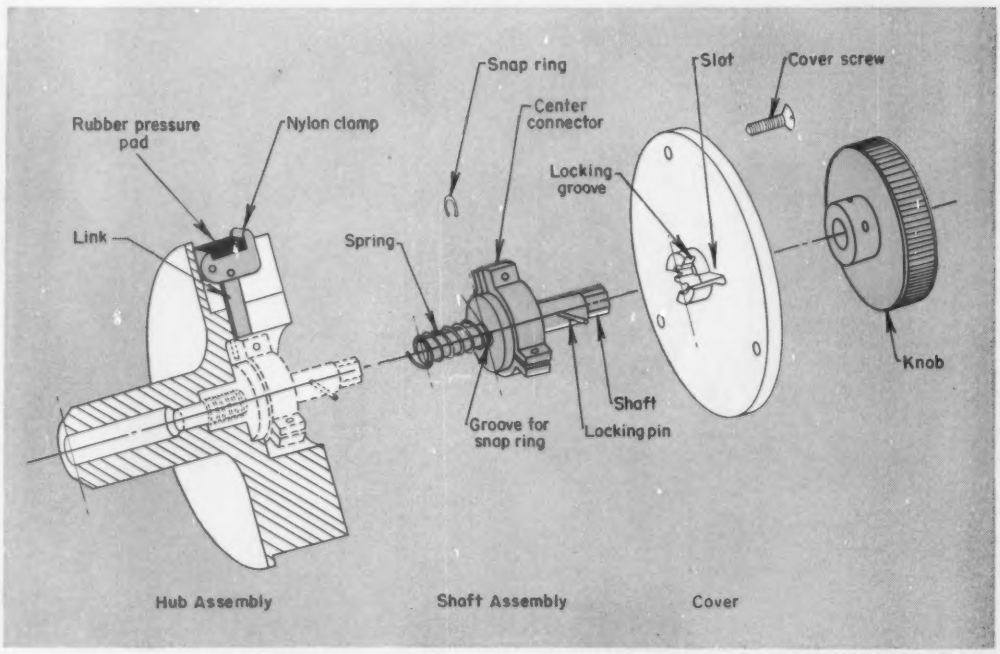
Self-locating stop automatically adjusts brake-shoe clearance to compensate for wear of friction surface. A friction fit between the spring-loaded stop pin and the return bushing permits the pin to withdraw the piston when the brake pedal is released. However, when clearance between the brake shoe and the friction surface becomes excessive, hydraulic pressure produced by the master cylinder forces the piston to slide along the pin to a new position. Principle developed by Deutsche Dunlop Gummi Compagnie AG, Hanau/Main, Germany.



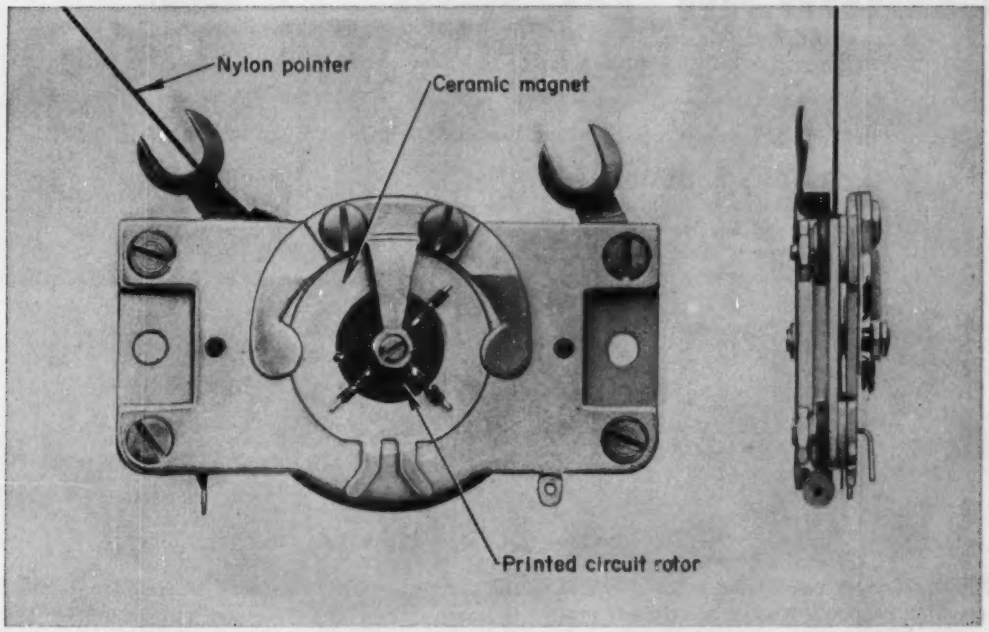
SCANNING THE FIELD FOR IDEAS

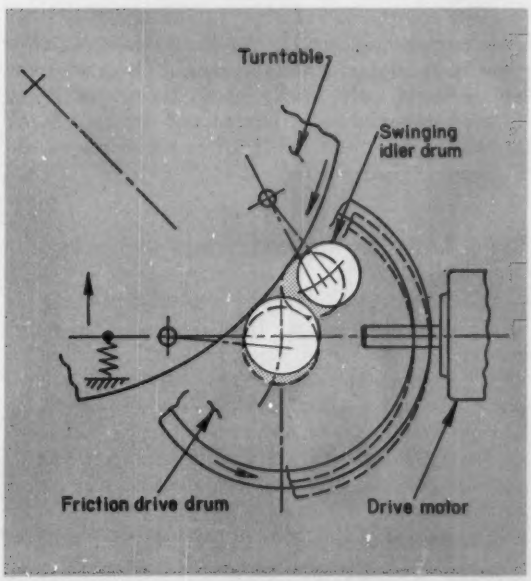
Linkage-controlled fingers simplify mounting and removal of reels on a tape drive. Axial movement of the handwheel operates the fingers in unison through the center connector. A quarter turn of the handwheel permits the spring-loaded locking pin to engage the locking groove. The mechanical advantage of the four-bar linkage produces adequate clamping force without excessive handwheel loads. Principle employed in tape reel holder reported by Frank Elksnin, Mitre Corp., Lexington, Mass.





Printed circuit on metal rotor permits extremely thin meter construction. Surface of the aluminum disc is anodized to insulate the circuit from the rotor. The aluminum disc also provides damping of the 3/8-in. thick meter. The flexible nylon pointer is not damaged by shock contact with stops caused by extreme meter overloads. Metallic-base printed circuit employed in electrical meter developed by Interlab Inc., Bronxville, N. Y.





Swinging-idler drive provides quick-reverse rotation for a recorder turntable. For regular rotation, a friction-drive drum transmits the power from the drive motor to the turntable. To reverse the turntable, an idler drive drum is swung against the main drum, forcing it aside. The main drum then drives the idler, which in turn, drives the turntable. Control principle employed in recorder developed by Telefunken GmbH, Hannover, Germany.

How to use four basic concepts to speed and improve

Mechanism Design

1. Constraint
2. Toggle Effect
3. Rotation
4. Inversion

THOMAS P. GOODMAN
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BY DEFINITION, a mechanism is an assembly of machine elements having constrained motion. The first step in any kinematic design is an understanding of the nature of constrained motion and an investigation of the constraints necessary to achieve it in a given mechanism. In a simple mechanism, the conditions for constrained motion can usually be determined by inspection, but in complex mechanisms a systematic procedure for investigating the constraints is essential.

Constrained motion may be defined as motion of an assembly of parts, with one or more movable inputs, in which the motions of all parts are completely determined from the input motions. The number of degrees of freedom which a mechanism has is the number of independent variables or coordinates required to specify its motion. Thus, in order to have constrained motion, a mechanism must have as many degrees of freedom as it has inputs.

Usually a mechanism has a single input motion and must therefore have a single degree of freedom. On the other hand, a mechanism with two separate inputs, such as a differential mechanism, must have two degrees of freedom.

A mechanical assembly can transmit power from an input to an output member only if it has constrained motion. If there are too few degrees of freedom, the assembly cannot move at all and thus becomes a structure rather than a mechanism. If there are too many degrees of freedom, the motion is unconstrained and no power can be transmitted. A familiar example of this condition is the rear-wheel drive of an automobile when one wheel slips relative to the ground. The slipping gives the drive an extra degree of freedom, and no power can be transmitted to the other wheel.

Essential to a clear understanding of constrained motions and to the investigation and design of complex mechanisms are the kinematic concepts of a rigid body and a kinematic pair. These concepts are reviewed only briefly here. References 1* to 11 are representative of foreign and domestic books in which these and other kinematic concepts are discussed in greater detail.

Rigid Bodies in Kinematics and Dynamics

Kinematics is primarily a study of the relative motions of rigid bodies. In a rigid body, any two points remain a fixed distance apart regardless of the motion of the body. The motion of a rigid body in a plane can be described completely by stating the motion of any two points in the body, or simply the motion of the line segment joining the two points, as for example, the points *A* and *B* or the line *AB* in Fig. 1.

The motion of this body in the plane of the paper

*References are tabulated at end of article.

Linkages can satisfy a host of motion-transformation requirements. But, despite their simplicity, they can be frustrating: There's often no easy, clear-cut way to find those proportions that will produce a prescribed output motion.

This series of four articles will outline a practical approach to the problem. Methods presented shorten the common cut-and-try process and, yet side-step the complexity of kinematic synthesis.

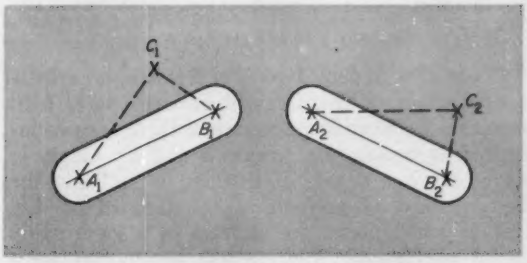

Fig. 1—Two positions of a rigid body.

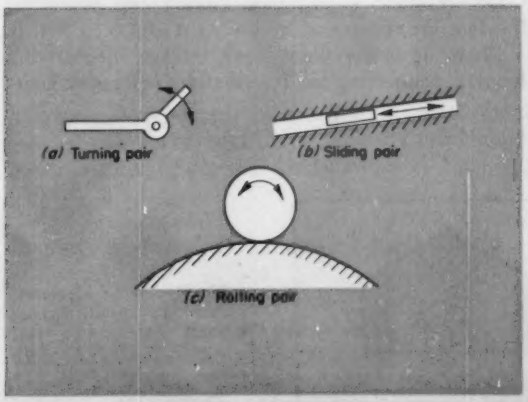

Fig. 2—Planar kinematic pairs.

from position 1 to position 2 is described completely by the motion of points A and B from positions A_1 and B_1 to positions A_2 and B_2 or by the motion of the line AB from position A_1B_1 to position A_2B_2.

In kinematics, a rigid body is regarded as being infinite in extent. Any point in space may be regarded as a point on the rigid body, whether or not it is a point on the machine part itself. For example, point C_1 in Fig. 1, although it lies outside the outline of the body, may be considered as a point on the rigid body in position 1. Since distances AC and BC must remain fixed, point C_2 in position 2 of the bod, which corresponds to point C_1 in position 1 may be found by constructing triangle $A_2B_2C_2$ congruent to triangle $A_1B_1C_1$.

In spatial or three-dimensional kinematics, the motion of a rigid body can be described completely by stating the motion of any three noncollinear points on the body, or simply the motion of the triangle joining these three points. When the motion is not confined to a plane, two views of the body are necessary for a graphical representation of the motion.

In dynamics, the forces in a mechanism are usually first computed on the assumption that the parts of the mechanism, except for springs, are rigid bodies. Since no physical object can remain completely rigid when acted upon by forces, the deformations of the parts due to the forces are then computed. Motion as a consequence of deforma-

tion is ordinarily small compared to the rigid-body motion. It can be added to the rigid-body motion as a small correction, which may take the form of a vibration or oscillation.

Kinematic Chains and Pairs

A kinematic chain is a series of rigid bodies which are joined together in such a way as to permit relative motion between them. The bodies that comprise a kinematic chain are sometimes called links. Two links in contact form a kinematic pair. Common types of pairs in planar mechanisms are

1. Turning pairs, Fig. 2*a*, which permit only rotation of one link relative to another.
2. Sliding pairs, Fig. 2*b*, which permit only linear displacement of one link relative to another.
3. Rolling-contact pairs, Fig. 2*c*, which permit only rolling motion of one link relative to another. In a rolling-contact pair, the two surfaces must be held in contact by some external force or constraint; also, there must be enough friction to prevent relative sliding motion of the surfaces.

Degrees of Freedom in Planar Mechanisms

The number of degrees of freedom which a body has is the number of independent variables or co-ordinates required to specify its motion. A link connected to the frame of a machine by a turning pair, a sliding pair, or a rolling-contact pair has only one degree of freedom since the turning, sliding, or rolling motion can be specified by one co-ordinate, either an angular or a linear displacement. Pairs permitting only one degree of freedom are called lower pairs. A link connected to the frame in such a manner that it rolls and slides or it turns and slides has two degrees of freedom. Such pairs are called higher pairs.

A link which is free to move in a plane and is not connected to the frame has three degrees of freedom, since it can have linear displacements in two directions as well as an angular displacement, Fig. 3. A link which is free to move in space has six degrees of freedom, since it can have three independent linear and angular displacements.

The number of degrees of freedom of a chain of links connected together can be determined by adding together the number of degrees of freedom in each link separately and then subtracting the number of constraints introduced by each pair. Thus, for a planar mechanism, each link except the fixed link or machine frame has three degrees of freedom when not connected to any other link. When connected, however, each higher pair reduces the number of degrees of freedom by one; each lower pair reduces the number of degrees of freedom by two. These statements can be combined into an equation:

$$f = 3(n - 1) - h - 2l \qquad (1)$$

where f = number of degrees of freedom of the chain, n = number of links, including one fixed link, h = number of higher pairs, and l = number of lower pairs.

To illustrate the application of Equation 1, consider the chains of links in Fig. 4. All have only turning pairs. For chain *a*:

$$n = 3, \quad h = 0, \quad l = 3; \quad f = 0$$

For chain *b*:

$$n = 4, \quad h = 0, \quad l = 4; \quad f = 1$$

For chain *c*:

$$n = 5, \quad h = 0, \quad l = 5; \quad f = 2$$

Chain *a*, with zero degrees of freedom, is actually a rigid structure; chain c, with two degrees of freedom, is a useful mechanism only if there are two independent inputs (e.g., cranks *a* and *d*). Chain *b*, with only one degree of freedom, is probably the best-known of all mechanisms: the standard four-bar linkage which forms the skeleton of a great many useful mechanisms. A convenient terminology for a four-bar linkage is the use of *a* for the driving crank, *b* for the coupler or connecting rod, c for the driven crank or rocker, and *f* for the frame or fixed link. Other common mechanisms having one degree of freedom are illustrated by chains *a* and *b* in Fig. 5.

Chain 5*a* is the slider-crank linkage with driving crank *a*, connecting rod *b*, and slider *c*. Its most com-

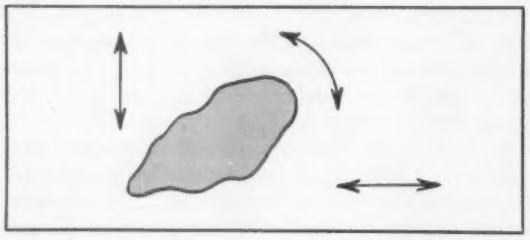

Fig. 3—Degrees of freedom of a rigid body in a plane.

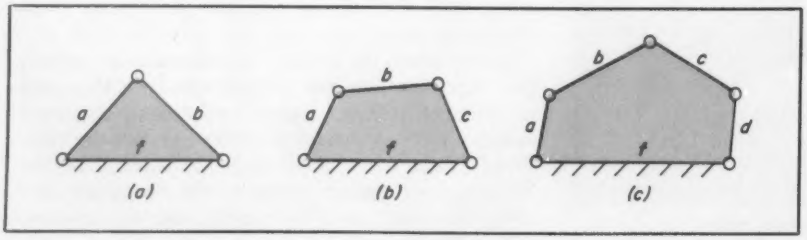

Fig. 4—Planar kinematic chains having all turning pairs.

mon application is in an engine, with a as the crankshaft, b as the connecting rod, and c as the piston. It has four links, including the frame f, with three turning pairs at A, B, and C and a sliding pair between links c and f. From Equation 1,

$$n = 4, \quad h = 0, \quad l = 4; \quad f = 1$$

Chain 5b is a cam with a sliding flat-faced follower. There are three links: Cam a, follower b, and frame f. There is a turning pair at A, a sliding pair between links b and f, and a higher pair at B. From Equation 1

$$n = 3, \quad h = 1, \quad l = 2; \quad f = 1$$

These examples are simple enough so that the number of degrees of freedom could be determined by inspection. However, in a more complicated linkage the number of degrees of freedom is not so obvious, and then Equation 1 can be helpful in determining whether a mechanism has constrained motion or not. For example, apply Equation 1 to the chain of Fig. 6:

$$n = 6, \quad h = 0, \quad l = 7; \quad f = 1$$

Therefore chain 6 has constrained motion.

There is one situation in which Equation 1 as it stands is misleading. If a point in a mechanism is already constrained to move in a given path, then the introduction of an additional link or guide which also constrains the point to move in the same path does not actually reduce the number of degrees of freedom, even though Equation 1 would indicate that it does. Such an additional link or guide is known as a superfluous or redundant constraint.

For example, in the parallel-crank linkage shown in Fig. 7, in which $AB = CD$ and $AD = BC$, each point of the coupler b is constrained to move in a circular arc with radius $AB = CD$. The introduction of an additional link, with two turning pairs, connecting coupler b to frame f should reduce the number of degrees of freedom to zero, since by Equation 1

$$n = 5, \quad h = 0, \quad l = 6; \quad f = 0$$

If the new link joins point E and F, this is indeed the case; however, if the new link joins points E and G where EG, CD, and AB are parallel at all positions, no new constraint is introduced since G is already constrained to move in a circular arc with center at E. In this case, Equation 1 gives the wrong answer, $f = 0$, whereas actually $f = 1$.

To allow for the possibility of redundant constraints, Equation 1 should be re-written as an inequality:

$$f \geq 3(n - 1) - h - 2l \qquad (2)$$

The inequality becomes an equality only when there are no redundant constraints. Usually, redundant constraints can be detected by inspection.

Degrees of Freedom in Spatial Mechanisms

Since a link which is free to move in space can have three independent linear displacements and three independent angular displacements, it has six degrees of freedom. If two links are connected by a pair having one degree of freedom, the total number of degrees of freedom of the two links is reduced by $(6 - 1)$, or 5; similarly, if two links are connected by a pair having f_i degrees of freedom, the total number of degrees of freedom is reduced by $(6 - f_i)$.

Thus, the total number of degrees of freedom, f, of a spatial mechanism with one link fixed is

$$f \geq 6(n - 1) - \sum_{i=1}^{p} (6 - f_i)$$

or

$$f \geq 6(n - p - 1) + \sum_{i=1}^{p} f_i \qquad (3)$$

where n = number of links, including the fixed link, and p = number of pairs. As in planar mechanisms,

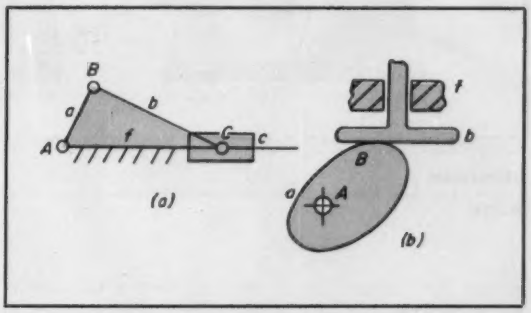

Fig. 5—Slider crank and cam-type planar kinematic chains.

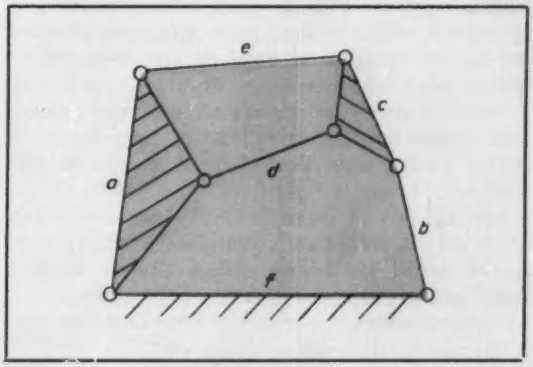

Fig. 6—Six-link planar kinematic chain.

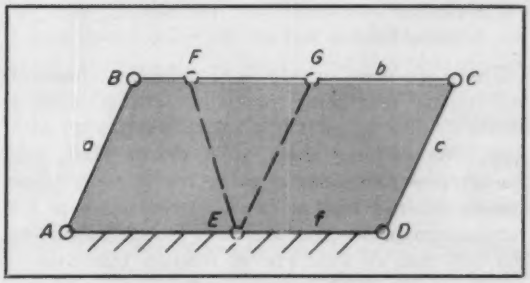

Fig. 7—Parallel-crank linkage with redundant constraint.

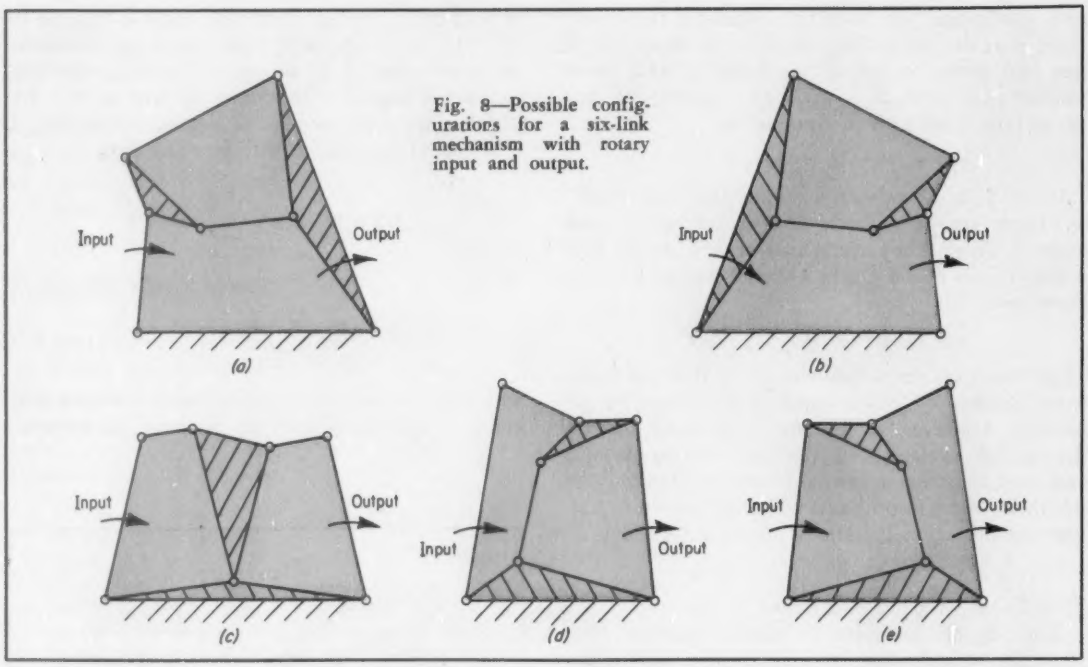

Fig. 8—Possible configurations for a six-link mechanism with rotary input and output.

the inequality sign becomes an equality sign when there are no redundant constraints.

Examples of pairs having one degree of freedom are lower pairs of the same types found in planar mechanisms, i.e. turning pairs, sliding pairs, and cylindrical rolling-contact pairs. Examples of pairs having two degrees of freedom are turning-and-sliding pairs, which permit a shaft to move axially as well as to rotate, planar surface-contact pairs, and spherical rolling-contact pairs. An example of a pair having three degrees of freedom is a ball-and-socket joint.

Investigation of Equation 3 discloses that when there are no redundant constraints, a simply connected spatial mechanism with a number of pairs equal to the number of links needs a total Σf_i of 7 for constrained motion of $f = 1$. Some of the mechanisms which fulfill this condition are:

1. A seven-link mechanism with seven turning pairs.
2. A four-link mechanism with one turning pair and three turning-and-sliding pairs.
3. A four-link mechanism with two turning pairs, one turning-and-sliding pair, and one ball-and-socket joint.

There are many examples of spatial mechanisms which have redundant constraints. For example, a Hooke's universal joint is a spatial mechanism with four links (driving shaft, yoke, driven shaft, and frame) and four turning pairs, but it nevertheless has constrained motion ($f = 1$). In this case the redundance in the constraints is brought about by the fact that all four axes of rotation (the axes of rotation of both shafts with respect to the frame and of both shafts with respect to the yoke) intersect in a common point.

Application of Constraint Concept

In a kinematic design it is usually desirable to investigate several alternative approaches to a problem. The criterion for constrained motion gives the basic ground rule for alternative approaches. By applying this criterion, all possible linkages of a given degree of complexity can be investigated. Any promising approach is not likely to be overlooked.

For a planar linkage with only lower pairs and with a single input, the constraint criterion indicates that number of pairs l required for constrained motion is

$$l = \frac{3}{2} n - 2 \qquad (4)$$

Thus, number of links n must be an even number; possible combinations of n and l are

1. Two links with one lower pair (a trivial case).
2. Four links with four lower pairs.
3. Six links with seven lower pairs.
4. Eight links with ten lower pairs, and so on.

If a given motion problem cannot be solved by a four-link mechanism, then this analysis tells us that the next step in complexity is a six-link mechanism, and that the six-link lower-paired mechanism must have seven lower pairs. From this knowledge, all possible six-link mechanisms of a given type can be constructed. For a six-link mechanism having only turning pairs, with rotary input and output cranks, there are five possible configurations, Fig. 8.

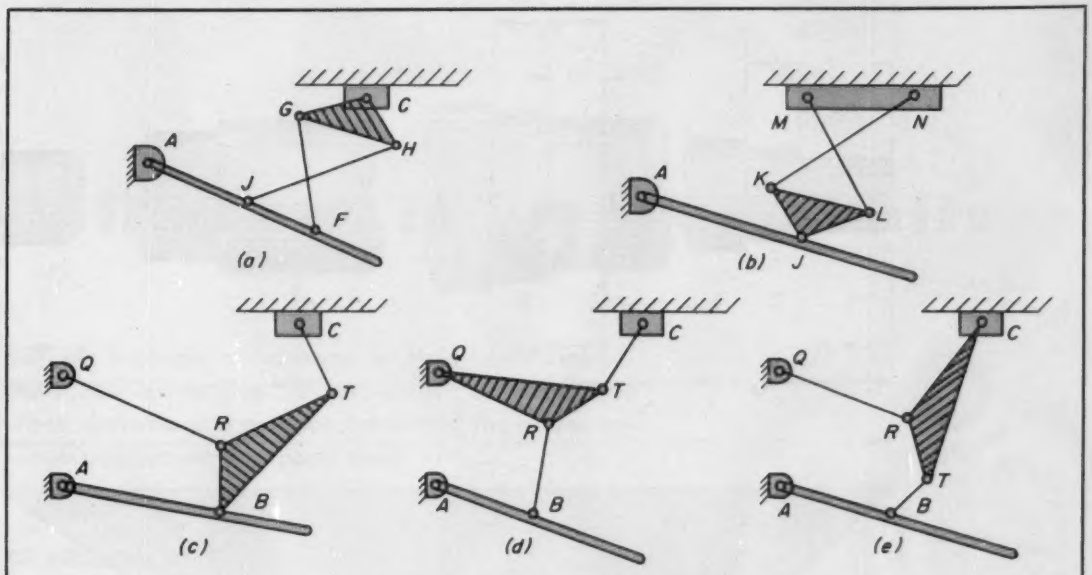

Fig. 9—Possible configurations of a six-link mechanism for converting translation to rotary motion.

For a six-link mechanism converting translational to rotary motion, there are five possible configurations, Fig. 9.

If a six-link mechanism still will not meet the requirements of a design, then an eight-link mechanism can be investigated. Hain[2] has investigated the possible link and pair combinations in eight-link mechanisms. Knowledge of alternative designs is also valuable in obtaining complete patent coverage for an idea which may have alternative engineering embodiments.

Elimination of Redundant Constraints

Redundant constraints are usually undesirable in a design because they can cause friction and binding if not held to exact tolerances. However, for a mechanism with constrained motion and no redundant constraints, dimensional errors in parts can cause slight deviations from the desired output motion but cannot cause binding. A constraint analysis will usually reveal redundant constraints, which can then be eliminated if desired.

A special case of redundant constraints is in mechanisms designed for zero degrees of freedom. If one surface is located with respect to another so that the constraint equation gives zero degrees of freedom, then the part will have a definite location. If the constraint equation gives less than zero degrees of freedom, then there are one or more redundant constraints and the part will not be accurately located. Several examples of this principle have been given by Spotts.[12]

The most familiar example of this principle is a tripod. For a body in space, three noncollinear points of contact with a plane give, $f = 0$. The first point of contact, taken by itself, may be regarded as a spherical rolling pair with two degrees of freedom, and each of the other two points of support removes one of these degrees of freedom. As is known from experience, a three-legged support can never wobble, although an error in the length of a leg can cause an error in the position of the part being supported. However, a four-legged support (for which $f = -1$) can wobble if there is a dimensional error in the length of a leg.

This principle, which is quite evident in the case of a tripod, can be readily applied to more complicated situations by a constraint analysis.

ACKNOWLEDGMENT

This article is based on a paper presented at the Sixth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 10-11, 1960.

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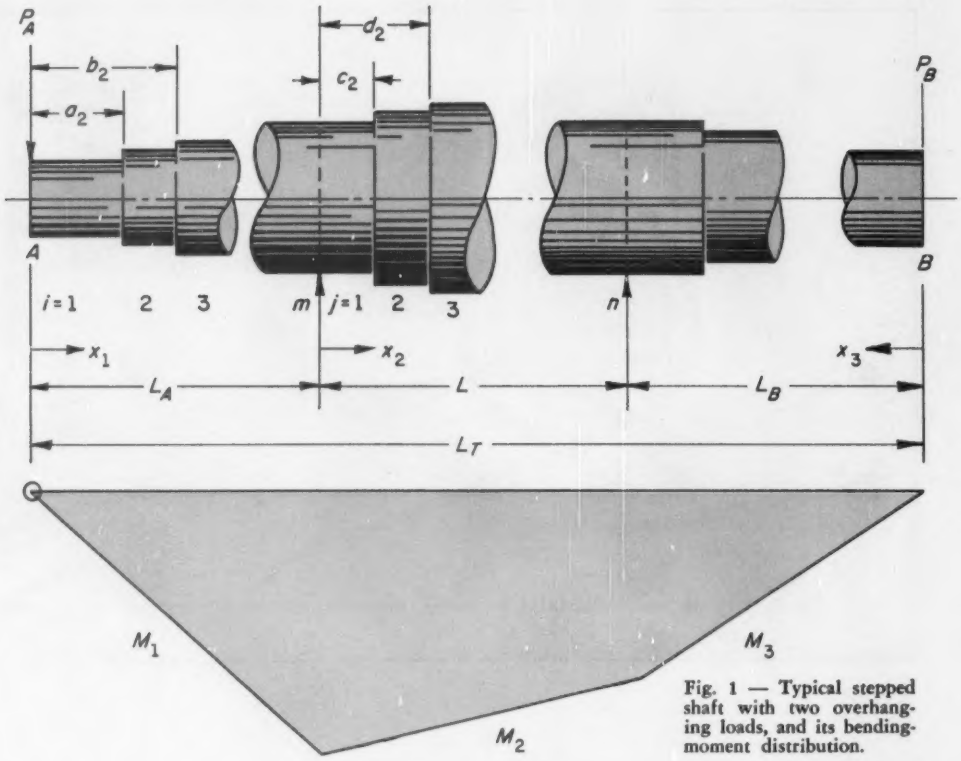

Fig. 1 — Typical stepped shaft with two overhanging loads, and its bending-moment distribution.

LIKE a beam, a shaft bends and deflects under loads. Deflections as the consequence of loads are often the criterion of shaft design—particularly in machine tools, turbines, speed reducers. Deflections are used also in vibration analysis and in calculations to predict the critical speeds of shafts.

For a given loading, calculating the deflections of a stepped shaft is more complicated than calculating the deflections in a shaft of equal length but of uniform diameter. Most methods of determining deflections in stepped shafts involve either the solution of the second-order, linear, differential equation that applies to small deflections of straight beams, or the solution of its finite-difference equivalent.

Castigliano's strain-energy method, on the other hand, uses the techniques of the calculus of variations. It is simpler than other methods. It is better suited to the calculations of deflections at selected points along a shaft than for calculating a deflection curve over the entire shaft length. When desired, it can be used for rapid calculations by slide rule.

This method of Castigliano, relatively unknown, merits consideration and wider usage. Applications of the method are illustrated here, and the theory of it is reviewed.

Strain-Energy Theory

In accord with the theory of Castigliano, the strain energy, U, stored inside a structural member by virtue of its loading is expressed by

$$U = \int_0^{L_T} \frac{M^2 dx}{2EI} + \int_0^{L_T} \frac{\alpha V^2 dx}{2GA_c} \qquad (1)$$

When the loaded member is a stepped shaft, the integration must be performed separately for each constant-diameter or tapered segment.

Castigliano's second theorem states that the deflection y_0 (or the slope θ_0) at a point 0 is equal to the partial derivative of the total strain energy with respect to the load P_0 (or the moment M_0) applied at that point. Mathematically,

$$y_0 = \frac{\partial U}{\partial P_0} \qquad (2)$$

$$\theta_0 = \frac{\partial U}{\partial M_0} \qquad (3)$$

Equations 2 and 3 are combined with Equation 1 by partially differentiating inside the integral to get

$$y_0 = \int_0^{L_T} \frac{M \dfrac{\partial M}{\partial P_0} dx}{EI} + \int_0^{L_T} \frac{\alpha V \dfrac{\partial V}{\partial P_0} dx}{GA_c} \qquad (4)$$

and

$$\theta_0 = \int_0^{L_T} \frac{M \dfrac{\partial M}{\partial M_0} dx}{EI} + \int_0^{L_T} \frac{\alpha V \dfrac{\partial V}{\partial M_0} dx}{GA_c} \qquad (5)$$

Most stepped shafts are long in comparison with

Deflections in Stepped Shafts

Suitable for rapid calculations, by slide rule if desired, Castigliano's method is especially advantageous when deflections are to be calculated for a few selected positions in a stepped shaft.

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the largest diameters. The effect of vertical shear[1] upon deflection and slope is usually negligible in comparison with the effect of bending moment. Accordingly, Equations 4 and 5 are simplified by disregarding the last terms.

There is another well-known energy theorem called the principle of virtual work (or Castigliano's first theorem) which states that the load (or moment) at the particular point is equal to the partial derivative of the total strain energy with respect to the deflection (or slope) at that point.

Sometimes this method is used to determine the loads at fixed points where the deflections are zero. However, since energy methods are generally not as accurate for determining loads or moments as they are for calculating deflections, the moment-distribution method[2] is recommended for calculating loads and moments in shafts in an indeterminate-beam category. Shafts supported by three bearings are illustrative of this category.

Application to Stepped Shafts

A typical stepped shaft with two concentrated-load supports and two coplanar, concentrated, overhanging loads at each end is shown in Fig. 1. This figure also shows the bending-moment diagram corresponding to this loading.

Mathematical expressions for the bending mo-

[1]References are tabulated at end of article.

Nomenclature

A = Deflection due to a unit load applied at the mass center of rotor, in. per lb
A_s = Cross-sectional area of shaft, in.^{2}
B = Deflection due to a unit bending couple applied at the mass center of the rotor, in. per lb-in.
C = Slope due to a unit bending couple applied at the mass center of the rotor, rad per lb-in.
$\bar{c}_j = L - c_j$
$\bar{d}_j = L - d_j$
E = Modulus of elasticity, psi
G = Modulus of rigidity, psi
I_i = Moment of inertia in ith portion of the shaft, in.^{4} (Denoted as I_1, I_2, . . . in numerical examples.)
I_j' = Moment of inertia in jth portion of the shaft, in.^{4} (Denoted as I_1', I_2', . . . in numerical examples.)
I_d = Mass moment of inertia of rotor about its axis minus the mass moment of inertia of rotor about a diameter, lb-in.-sec^2
I_s = Sum of mass moment of inertia of rotor about its axis and the mass moment of inertia of rotor about a diameter, lb-in.-sec^2
L = Distance between shaft supports, in.
L_A, L_B = Shaft overhang of left and right ends, respectively, in.
M = Bending moment or couple, lb-in.
m_r = Mass of rotor, lb-sec^2 per in.
P = Applied load, lb
U = Strain energy, in.-lb
V = Vertical shear force, lb
y = Deflection of shaft, in.
α = Shear-deflection shape factor (1.11 for a solid round shaft; 2.00 for a thin-walled tube)
ω_{b1}, ω_{b2} = Critical whirling speed for backward precession of the first and second types, respectively, rpm
ω_f = Critical whirling speed for forward precession, rpm
ω_n = Critical whirling speed, neglecting gyroscopic effects, rpm
θ = Slope of shaft, rad

ments in the portions of the shaft to the left of the left-hand support (portion 1), between the supports (portion 2), and to the right of the right-hand support (portion 3), respectively, are

$$M_1 = -P_A x_1 \tag{6}$$

$$M_2 = -P_A L_A + \frac{(P_A L_A - P_B L_B) x_2}{L} \tag{7}$$

$$M_3 = -P_B x_3 \tag{8}$$

The partial derivatives of Equations 6, 7, and 8 with respect to load P_A at the left end are

$$\frac{\partial M_1}{\partial P_A} = -x_1 \tag{9}$$

$$\frac{\partial M_2}{\partial P_A} = -L_A \left(1 - \frac{x_2}{L}\right) \tag{10}$$

$$\frac{\partial M_3}{\partial P_A} = 0 \tag{11}$$

These derivatives are substituted into Equation 4 (disregarding the last term) and the integration performed to obtain an expression for the deflection

$$y_A = \frac{1}{E}\left\{\sum_{i=1}^{m} \frac{P_A(b_i^3 - a_i^3)}{3I_i} + L_A \sum_{j=1}^{n}\left[\frac{C_1(d_j - c_j)}{I_j'} - \frac{C_2(d_j^2 - c_j^2) + C_3(d_j^3 - c_j^3)}{I_j'}\right]\right\} \tag{12}$$

where

$$C_1 = P_A L_A \tag{13}$$

$$C_2 = \frac{2P_A L_A - P_B L_B}{2L} \tag{14}$$

$$C_3 = \frac{P_B L_B - P_A L_A}{3L^2} \tag{15}$$

EXAMPLE 1: Fig. 2 represents the spindle of a typical grinding machine in dimensions, loads, and reactions. The dynamic effects are assumed as negligible in comparison with the high static forces.

Evaluation of Equations 13, 14, and 15 give

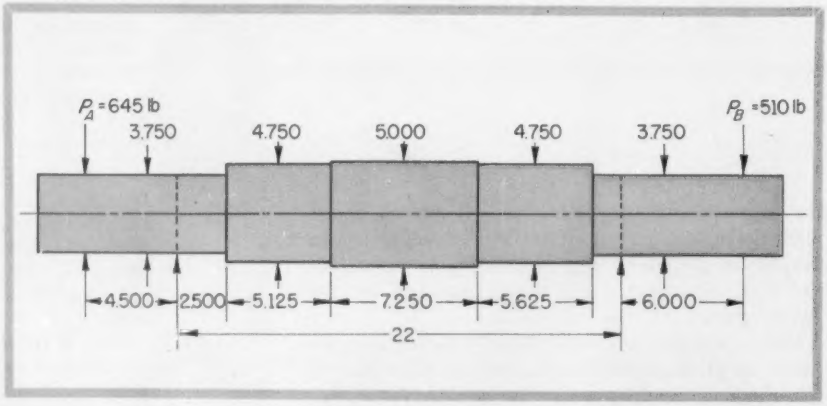

Fig. 2—Dimensional data for the grinding-machine spindle of Example 1. All dimensions are in inches.

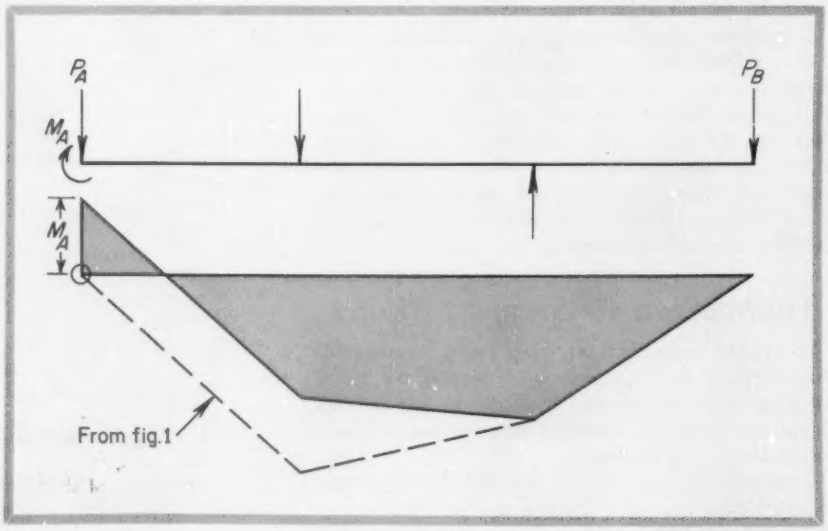

Fig. 3—Addition of a dummy moment M_A and the resulting moment diagram.

$$C_1 = 645(4.5) = 2900$$

$$C_2 = \frac{2(2900) - 510(6.0)}{2(22)} = 62.4$$

$$C_3 = \frac{510(6.0) - 2900}{3(22)^2} = 0.1088$$

The main computations in solving Equation 12 are best carried out in tabular form, Table 1. Each column represents one of the five constant-diameter segments of the shaft. The deflection y_A as calculated is 0.000314 in.

An equation for the slope, θ_A, is derived by the same procedure as that for deflections. The partial derivatives of Equations 6, 7, and 8 are formed with respect to M_A instead of P_A. These partial derivatives are put into Equation 5 and the integration performed to get

$$\theta_A = -\frac{1}{E}\left\{\frac{P_A}{2}\sum_{i=1}^{m}\frac{b_i^2 - a_i^2}{I_i} + \sum_{j=1}^{n}\left[\frac{C_1(d_j - c_j)}{I_j'} - \frac{C_2(d_j^2 - c_j^2) + C_3(d_j^3 - c_j^3)}{I_j'}\right]\right\} \quad (16)$$

Application of either Equation 12 or 16 depends upon the existence of an applied load or moment at the point. In the foregoing example, there is an applied load but no applied moment. Under the latter condition, a "dummy" moment M_A is added, the partial derivatives are formed with respect to the dummy, and then M_A is set equal to zero. Fig. 3 illustrates a beam with a dummy loading and its corresponding moment diagram.

Critical Whirling Speed

Calculation of critical speeds for whirling vibration can include gyroscopic effects. A typical example would be the overhung rotor of a large, high-speed, centrifugal compressor.

If gyroscopic effects are neglected, there is only one critical whirling speed for a given machine. If mass of the shaft is negligible in comparison to the mass of the rotor, the critical speed can be computed by

$$\omega_n = \frac{60}{2\pi\sqrt{A\,m_r}} \quad (17)$$

This whirling motion of a shaft is a circularly polarized motion (that is, motion in a small circular path). Yet the numerical value of the critical speed, neglecting gyroscopic effects, is identical to its natural or resonant frequency for lateral (but nonrotational) vibration.

When a shaft carrying a rigidly mounted, unsymmetrical rotor deflects because of ordinary whirling vibration, the axis of the rotor is tilted with respect to the axis of rotation. An unsymmetrical rotor is defined as any rotor which is not mounted at the center of symmetry of a shaft. Examples include the overhung rotor considered here (an extreme case), rotors mounted midway between bearings on shafts with nonsymmetrical distributions of moments of inertia, and rotors not mounted midway between bearings of a symmetrical shaft.

When a rotating rotor is tilted, the dynamic effect produced is a restoring or gyroscopic moment which tends to turn the rotor toward the untilted position, Fig. 4*a*. The net result of this gyroscopic moment is a decrease in the effective compliance,

Deflections in Stepped Shafts by Other Methods

1. *The graphical funicular-polygon method*[2,4] was originated by Culmann and Mohr nearly a century ago. Although it is somewhat tedious and time-consuming, this traditional method is still probably the best to determine the deflections along the entire length of a stepped shaft. The moment-distribution method[3] is recommended for calculating loads or moments in indeterminate beams.

2. *The area-integration method*[4] is quite rigorous, but is cumbersome to apply to stepped shafts.

3. *The finite-difference method*[5] involves setting up finite-difference equations which are equivalent to the original differential equations and then solving the difference equations using the principles of the calculus of finite differences. This method is well suited to computation by an electronic digital computer.

4. *The relaxation method*[6], originated by Sir Richard Southwell, is closely related to the finite-difference method.

5. *The conjugate-beam method*[7], developed by the late Professor Westergaard, can be applied to stepped shafts by using the concept of equivalent lengths to account for varying moments of inertia.

6. *The matrix method*[8] requires at least a basic understanding of matrix analysis to set up the solution in matrix form. However, this is an excellent method for digital-computer solution, particularly if a standard computer program for inverting higher-order matrices is available.

7. *The Laplace-transform method*[9] is quite powerful. Unfortunately, however, it probably requires more mathematical acuity than any of the other methods.

8. *The Hetenyi trigonometric-series method*[10] substitutes a unform-section beam loaded in such a manner that it is equivalent to the given variable-section beam.

Table 1—Tabular Calculations for Example 1

Item No.	Co-ordinate j	Position Between Supports 1	2	3	4	5
1	d_j	2.500	7.625	14.875	20.500	22.000
2	c_j	0	2.500	7.625	14.875	20.500
3	(1) − (2)	2.500	5.125	7.250	5.625	1.500
4	d_j^2	6.250	58.14	221.26	420.25	484.00
5	c_j^2	0	6.25	58.14	221.26	420.25
6	(4) − (5)	6.250	51.89	163.12	198.99	63.75
7	d_j^3	15.625	443.3	3291	8615	10648
8	c_j^3	0	15.63	443.3	3291	8615
9	(7) − (8)	15.625	427.7	2848	5324	2033
10	C_1·(3)	7256	14860	21000	16300	4350
11	$-C_2$(6)	−390	−3240	−10170	−12410	−3970
12	$-C_3$(9)	−1.7	−47	−310	−579	−221
13	(10) + (11) + (12)	6864	11573	10520	3311	159
14	I_j	9.692	24.96	30.68	24.96	9.692
15	L_A(13)/(14)	3190	2087	1467	597	74
16	Sum of (15) = 7415					
17	$P_A L_A^3/3I_A = 645(4.5)^3/(3)(9.692) = 2020$					
18	(16) + (17) = 9435					
19	$y_A = (18)/E = 9435/(30 \times 10^6) = 0.000314$ in.					

Table 2—Data for Example 2

$I_d = 19.5$ lb-in.-sec	$a_1 = 0$ in.	$b_1 = 2$ in.	$I_1 = 12.57$ in.^{4}
$I_s = 64.5$ lb-in.-sec	$a_2 = 2$	$b_2 = 6$	$I_2 = 20.2$
$m_r = 0.777$ lb-sec. per in.	$a_3 = 6$	$b_3 = 7$	$I_3 = 30.7$
$E = 30{,}000{,}000$ psi	$a_4 = 7$	$b_4 = 10$	$I_4 = 25.0$
$L_A = 10$ in.	$\bar{c}_1 = 0$	$\bar{d}_1 = 2$	$I_1' = 25.0$
$L = 20$ in.	$\bar{c}_2 = 2$	$\bar{d}_2 = 17$	$I_2' = 63.8$
	$\bar{c}_3 = 17$	$\bar{d}_3 = 20$	$I_3' = 25.0$

or deflection per unit load, of the shaft and thus an increase in the critical speed. This particular critical speed is known as the critical speed for forward precession and is[11]

$$\omega_f = \frac{60}{2\pi} \times \left[\frac{1}{\frac{1}{2}(Am_r - CI_d) + \sqrt{\frac{1}{4}(Am_r + CI_d)^2 - B^2 m_r I_d}} \right]^{\frac{1}{2}} \quad \ldots\ldots (18)$$

Another phenomenon encountered in a shaft carrying an unsymmetrical rotor is known as backward precession. This is a hypocyclic motion in which the center of the rotor moves with a backward velocity equal to the shaft speed. There are two distinct modes of bending during backward precession which are shown schematically in Fig. 4*b* and 4c. The critical speed for backward precession of the first type always occurs at a speed lower than the forward-precession critical speed and is given by

$$\omega_{b1} = \frac{60}{2\pi} \times \left[\frac{1}{\frac{1}{2}(Am_r + CI_s) + \sqrt{\frac{1}{4}(Am_r - CI_s)^2 + B^2 m_r I_s}} \right]^{\frac{1}{2}} \quad \ldots\ldots (19)$$

The second type of backward precession always occurs at a higher speed than the forward-precession critical speed and is given by

$$\omega_{b2} = \frac{60}{2\pi} \times \left[\frac{1}{\frac{1}{2}(Am_r + CI_s) - \sqrt{\frac{1}{4}(Am_r - CI_s)^2 + B^2 m_r I_s}} \right] \quad \ldots\ldots (20)$$

To calculate the compliances A, B, and C, it is first necessary to obtain expressions analogous to those of Equations 12 and 16, but for the case of an end load P_A and an end moment M_A:

$$y_A = \frac{1}{E}\left[\sum_{i=1}^{m}\left(P_A \frac{b_i^3 - a_i^3}{3I_i} - M_A \frac{b_i^2 - a_i^2}{2I_i}\right) + \right.$$

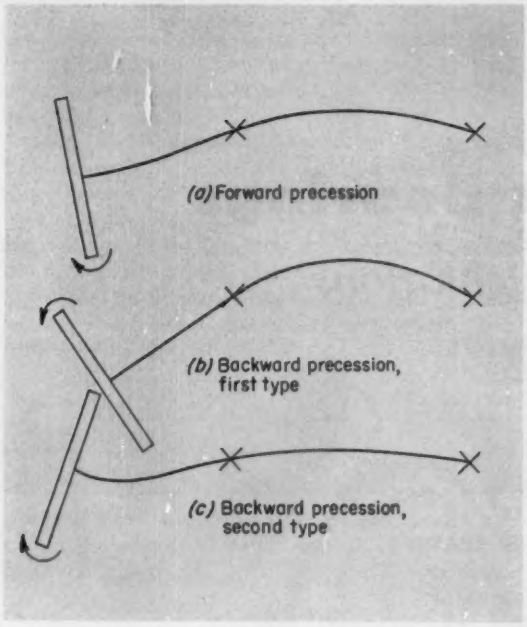

Fig. 4—Gyroscopic effects on deflections of a shaft carrying a heavy, overhung, rigidly mounted rotor. Arrows denote the direction of the gyroscopic couple for each case.

$$\sum_{j=1}^{n}\left(\frac{P_A L_A^2 - M_A L_A}{L^2}\right)\left(\frac{\bar{d}_j^3 - \bar{c}_j^3}{3I_j'}\right)\Bigg] \qquad (21)$$

and

$$\theta_A = \frac{1}{E}\Bigg[\sum_{i=1}^{m}\left(-P_A\frac{b_i^2 - a_i^2}{2I_i} + M_A\frac{b_i - a_i}{I_i}\right) + \sum_{j=1}^{n}\left(\frac{-P_A L_A + M_A}{L^2}\right)\left(\frac{\bar{d}_j^3 - \bar{c}_j^3}{3I_j'}\right)\Bigg] \qquad (22)$$

When P_B is absent the result is expressed in a simpler mathematical form by introducing $\bar{c}_j$ and $\bar{d}_j$.

Now the defining equations for the compliances are

$$y_A = AP_A - BM_A \qquad (23)$$

$$-\theta_A = BP_A - CM_A \qquad (24)$$

By inspection of Equations 21, 22, 23, and 24, and by considering unit values of P_A and M_A, the following expressions for the compliances are readily deduced

$$A = \frac{1}{3E}\Bigg[\sum_{i=1}^{m}\frac{b_i^3 - a_i^3}{I_i} + \frac{L_A^2}{L^2}\sum_{j=1}^{n}\frac{\bar{d}_j^3 - \bar{c}_j^3}{I_j'}\Bigg] \qquad (25)$$

$$B = \frac{1}{3E}\Bigg[\frac{3}{2}\sum_{i=1}^{m}\frac{b_i^2 - a_i^2}{I_i} + \frac{L_A}{L^2}\sum_{j=1}^{n}\frac{\bar{d}_j^3 - \bar{c}_j^3}{I_j'}\Bigg] \qquad (26)$$

$$C = \frac{1}{3E}\Bigg[3\sum_{i=1}^{m}\frac{b_i - a_i}{I_i} + \frac{1}{L^2}\sum_{j=1}^{n}\frac{\bar{d}_j^3 - \bar{c}_j^3}{I_j'}\Bigg] \qquad (27)$$

It should be observed that the compliances are defined in such a way that they are all always positive.

The pertinent data for this example are given in Table 2. Application of Equations 25, 26, and 27 give the following results: $A = (1.018) \times 10^{-6}$ in. per lb; $B = (0.1286) \times 10^{-6}$ in. per lb-in.; $C = (0.0227) \times 10^{-6}$ rad per lb-in. Finally, the critical whirling speeds, calculated by Equations 18, 19, 20, and 17 are: Forward precession, ω_f = 13,050 rpm; backward precession, first type, ω_{b1} = 6610 rpm; backward precession, second type, ω_{b2} = 24,100 rpm; and neglecting gyroscopic effects, ω_n = 10,700 rpm.

ACKNOWLEDGMENT

The author is indebted to Dr. H. D. Conway of the Department of Mechanics at Cornell University for suggesting this application of Castigliano's method. He acknowledges his indebtedness also to Professor M. S. Gjesdahl of the Department of Mechanical Engineering, Pennsylvania State Univ., for the data for Example 1.

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They Say . . .

". . . the scientific advances impelled by our defense needs have produced a fall-out of new knowledge; a beneficial fall-out that has helped to energize progress in many constructive directions."—S. E. SKINNER, *executive vice president, General Motors Corp.*

Wire-Race Antifriction Bearings

Part 2—Load Calculations

Fig. 1 — Single-row wire-race ball bearing carries simultaneous loads: F_a, axial; F_r, radial; M, tilting moment.

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Nomenclature

a = Length of contact area, in.
b = Width of contact area (width of race), in.
D_L = Pitch diameter, in.
d = Ball or roller diameter, in.
F_a = External axial load on bearing, lb
F_r = External radial load on bearing, lb
f = Friction factor, in.
f_L = Life factor
H = Brinell hardness, kg per sq mm
i_a = Number of rows subjected to axial loading
i_r = Number of rows subjected to radial loading
K_a = Axial load per ball, lb
K_o = Actual total load transmitted by one rolling element to one track wire, lb
$K_{o,max}$ = Maximum allowable total load that one rolling element can transmit to one track wire under combined static, dynamic, and tilt loading, lb
K_r = Radial load per ball, lb
M = Tilting moment, lb-in.
P_m = Axial load (because of tilt moment) on heaviest loaded ball, lb
P_o = Radial load on heaviest-loaded rolling element, lb
T = Turning resistance, lb-in.
w_a = Number of race wires of a single row of rolling elements transmitting axial load to bearing rings. For radial bearings, $w_a = 1$; for single and double-thrust bearings, $w_a = 2$
w_r = Number of race wires of a single row of rolling elements transmitting radial load to bearing rings. For both radial and thrust ball bearings, $w_r = 2$
z_a = Number of balls per row subjected to axial loading
z_r = Number of rolling elements per row subjected to radial loading
α = Angle of contact (between load axis and plane of rotation)

WIRE-RACE antifriction ball bearings are capable of carrying simultaneous radial, thrust, and tilting loads. Allowable distribution of these loads is determined by geometry of the bearing rings and position of the wire races in the rings.

This article, concluding the series, presents methods for determining maximum values for these various load conditions.

Depending on the type of duty to be performed by the wire-race antifriction bearing, its load-carrying capacity is limited primarily by one of the following criteria:

1. Static load-carrying capacity, where failure results in permanent deformation at contact areas between rolling elements and tracks to the extent that running properties of the bearing are affected.
2. Dynamic load-carrying capacity, where failure results in destruction of tracks because of material fatigue.
3. Fracture of a component of the bearing.
4. Deflection of the bearing (yielding under load).
5. Occurrence of wear so that play exceeds allowable value.

For the majority of cases, the critical factors affecting over-all load capacity of antifriction bearings —either conventional or wire-race types—are the static and dynamic load-carrying capacities. The first steps in computing wire-race antifriction bearings involve finding K_o and $K_{o,max}$.

Maximum Actual Load

External loads acting on a wire-race antifriction bearing are referred to the center of the bearing and resolved into components of axial, radial, and tilting loads, Fig. 1. For most design calculations, it is sufficient to add the maximum rolling-element load

values of these three components—assuming they occur at the same points in the bearing—to determine the maximum total load K_o.

Axial Load Component: Axial loads acting on a wire-race bearing are carried by ball elements; roller elements are suitable only for carrying radial loads. If the bearing is seated properly and the external forces are uniform, the axial load is distributed equally among all balls in the rows affected. Depending on the type of bearing, the ball load will be carried by either one or two race wires. Since balls are supported at an angle, α, on the race wires, Fig. 2, axial load per ball K_a includes a factor of $1/\sin\alpha$ and is represented by

$$K_a = \frac{F_a}{z_a i_a w_a \sin\alpha} \tag{1}$$

Radial Load Component: Maximum load P_o on a rolling element of a radially loaded antifriction bearing, Fig. 3, is

$$P_o = \frac{CF_r}{z_r}$$

where C is a constant whose value is selected from Table 1.

Load K_r exerted by the heaviest-loaded rolling element on one of the race wires is then found from

$$K_r = \frac{P_o}{i_r w_r \cos\alpha}$$

and, since with ordinary wire-race bearings the value of C is 5 and $P_o = 5F_r/z_r$, the equation can be rewritten as

$$K_r = \frac{5F_r}{i_r w_r z_r \cos\alpha} \tag{2}$$

Tilting Moment Component: Similar to the equation applying to a radially loaded antifriction bearing, the expression for load P_m of a bearing subjected to a tilting moment is

$$P_m = \frac{CM}{z_a D_L}$$

where, for the purpose of practical calculation, factor $C = 5$ for a wire-race antifriction bearing having a small amount of play. Therefore, for a wire-race bearing under pure tilting load, the load applied by the heaviest-loaded rolling element on one of the track wires is

$$K_m = \frac{5M}{i_a w_a z_a D_L \sin\alpha} \tag{3}$$

Load Summation: Total load K_o exerted by the heaviest-loaded rolling element on a single race wire is the sum of K_a, K_r, and K_m and can be written as

$$K_o = \frac{F_a D_L + 5M}{i_a w_a z_a D_L \sin\alpha} + \frac{5F_r}{i_r w_r z_r \cos\alpha} \tag{4}$$

Maximum Allowable Load

Load ratings for wire-race bearings are computed basically for a static condition, then modified for a specific dynamic service.

Static Loading: When loading occurs while the bearing is stationary or while movements are very slow, the static-load condition forms the basis for bearing design. Permanent deformation of races caused by external static loading of the bearing should not be so large that running properties of the bearing are impaired. Experience has shown that permissible contact pressure between a rolling

Table 1—Values of C

Condition	C Value
Bearing with line contact and zero play	4.00
Bearing with point contact and zero play	4.37
Bearing with moderate play	5.00

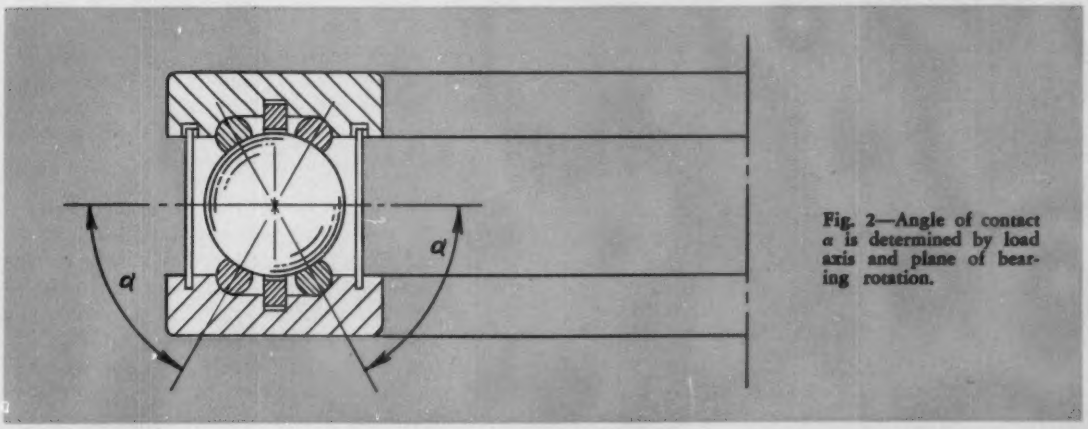


Fig. 2—Angle of contact α is determined by load axis and plane of bearing rotation.

element and the track is approximately proportional to the Brinell hardness, H, of the wire. The proportion can be a maximum of 0.41.

In wire-race ball bearings the contact area is assumed—because ball diameter is large in comparison to race width—to be that formed by a cylinder of diameter d which is pressed on a flat race of width b. The relation of contact length a to K_o and b is

$$a = \sqrt{\frac{4.6K_o d}{bE}} \qquad (5)$$

where E = modulus of elasticity of the track material, psi; d = ball diameter, in. Maximum permissible ball load $K_{o,\,max}$ is then determined as

$$K_{o,max} \leqq 0.41 \times 1422\, a\, b\, H \qquad (6)$$

A simplified and more usable equation for maximum permissible load of a rolling element on one race wire, which combines Equations 5 and 6, is

$$K_{o,max} = bd\left(\frac{H}{4.25}\right)^2 \qquad (7)$$

Generally, hardness of race wires increases with smaller diameters, Fig. 4. For this reason, wire diameters greater than 5/16 in. are seldom used. Any increase in load-carrying capacity gained by using heavier wires is nullified by their lower hardness.

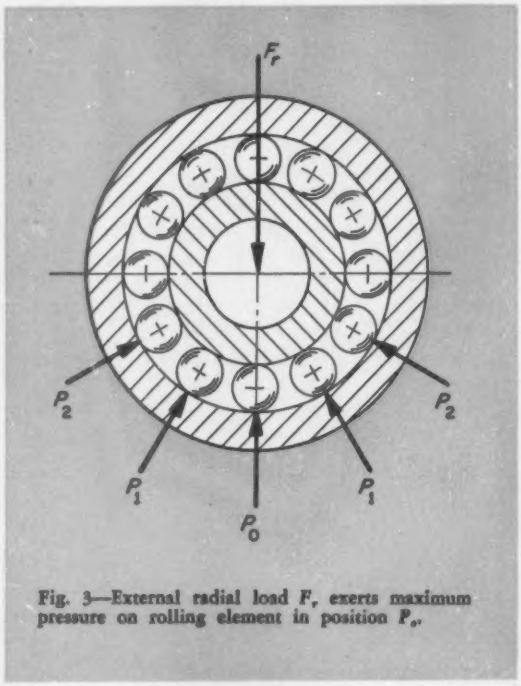


Fig. 3—External radial load F_r exerts maximum pressure on rolling element in position P_o.

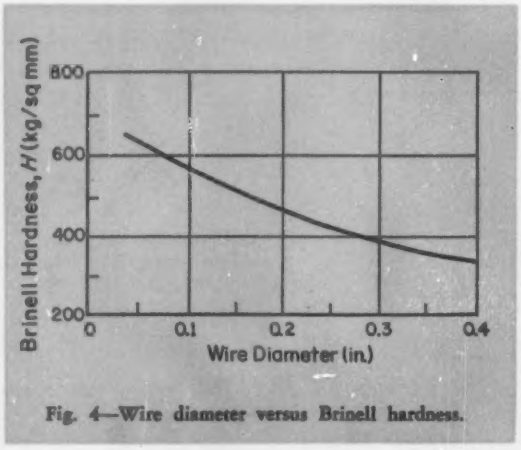


Fig. 4—Wire diameter versus Brinell hardness.

Dynamic Loading: As with conventional antifriction bearings, the dynamic load-carrying capacity of wire-race antifriction bearings is understood to mean the load at which 90 per cent of a large group of bearings, all of the same type and operating under identical conditions, will attain the theoretical life span.

Practical calculations of wire-race antifriction bearings incorporate a life factor, f_L. Maximum allowable rolling-element dynamic load on the race wire is

$$K_{o,max} = f_L bd\left(\frac{H}{4.25}\right)^2 \qquad (8)$$

where factor f_L depends upon bearing configuration and empirical application data.

Load-Capacity Summary: Hardness values of wire races made of large-diameter wires are lower than those of raceways of conventional antifriction bearings. The latter are usually in the range of 59 to 65 Rockwell C. This difference in hardness of the raceway surfaces reduces carrying capacity of certain wire-race antifriction bearings.

However, the load-carrying ability of wire-race ball bearings in use is greater than the hardness of races alone would indicate. This is because the rolling-in process results in an equal curvature of ball and raceway so that the contact between ball and race in an unloaded bearing is not a single point, as in conventional ball bearings, but a line, as in roller bearings. Also, most types of wire-race ball bearings are four-point-contact bearings; conventional ball bearings are usually two-point-contact bearings. Both of these factors—equal curvature and four-point contact between balls and their raceways—increase the load capacity of a bearing.

Tests have shown that the races of wire-race bearings do not remain stationary with respect to the bearing rings. Rotation occurs slowly during operation, and one revolution may be made in 10,000—or in 100,000—bearing revolutions, depending on bearing construction and operating conditions.

Race movement adds materially to the dynamic life of the bearing as compared to one with stationary-race design. In an application where a radial

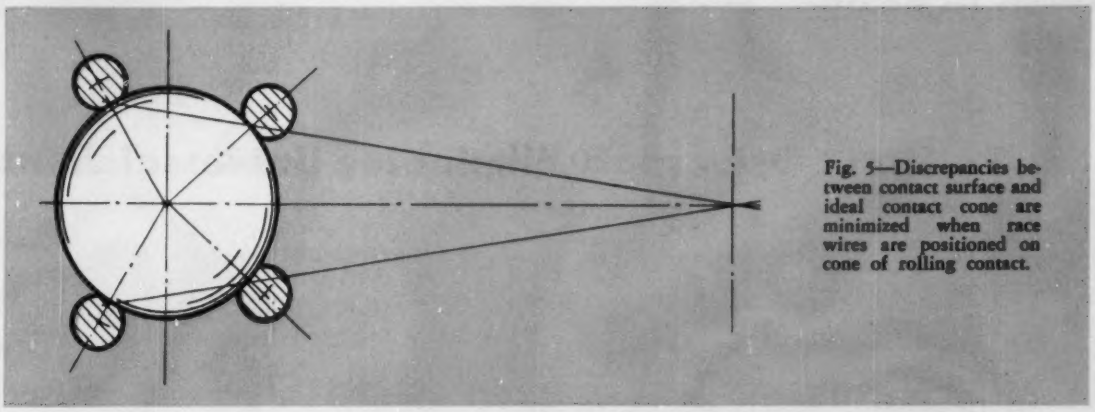


Fig. 5—Discrepancies between contact surface and ideal contact cone are minimized when race wires are positioned on cone of rolling contact.

bearing is loaded with a radial force—the most common case—the entire circumference of the race shares the load and the wear.

So many factors must be considered in comparing wire-race bearings with conventional antifriction bearings that definite conclusions are difficult to reach. In some applications, wire-race bearings offer superior performance or longer life; in others, the reverse is true. In general, and until a comparable volume of standard test data on wire-race bearings becomes available, static and dynamic load-carrying capacities of wire-race bearings can be considered similar to comparable conventional antifriction bearings.

Turning Resistance

The total turning resistance of a wire-race antifriction bearing is made up of the following components:

1. Rolling friction, consisting mainly of inner or molecular friction caused by elastic deformation of rolling elements and races.
2. Sliding friction at contact surfaces, caused by the failure of these surfaces to conform to the ideal contact cone, Fig. 5.
3. Sliding friction of rolling elements in contact with cages, spacer balls, or separators.
4. Resistance caused by the displacement of lubricant.
5. Resistance caused by foreign matter such as grit or abraded particles.

The magnitudes of these individual components that add up to total turning resistance depend further on several bearing factors: 1. Type. 2. Dimensions. 3. Loading. 4. Speed. 5. Lubrication.

These values vary widely for different types of wire-race bearings since, unlike conventional antifriction bearings, they are not made in a fixed range of sizes and listed in a catalog, but instead, are produced in a special design for each application.

For a radial wire-race ball bearing, loaded only in the axial direction, the turning resistance can be found by using the approximate formula:

$$T = \frac{D_L}{d} F_a f$$

where friction factor f = 0.001 to 0.004 in.

The turning resistance of the ball bearing can be minimized by positioning the wire races in the enclosing rings on the cone of rolling contact, Fig. 5, so that discrepancies between the actual contact surface and the ideal contact cone are slight. Generally, turning resistance of wire-race antifriction bearings is of the same order as that of conventional antifriction bearings.

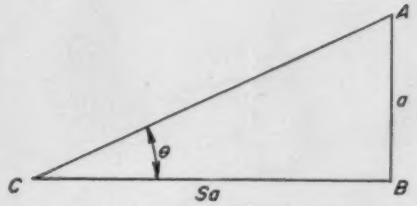
Tips and Techniques

Constructing an Angle

To draw an angle of 45 deg or less using only a ruler, first find the value of S in the formula

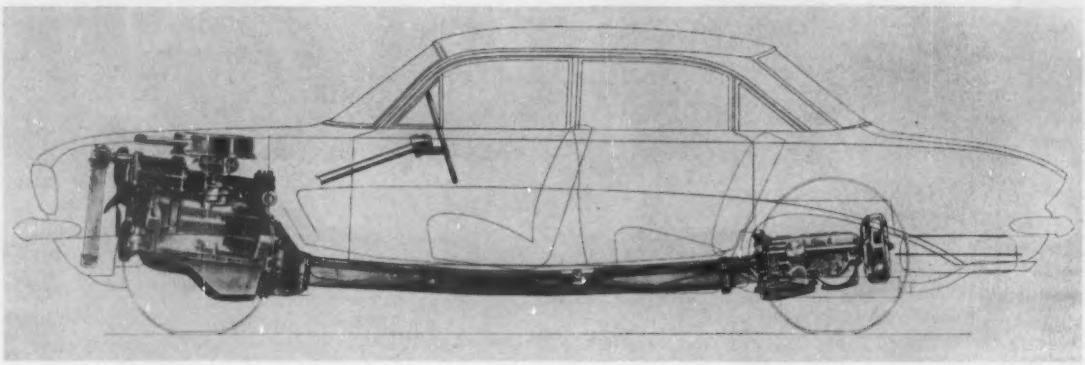
$$S = \frac{60}{\theta} - 0.3$$

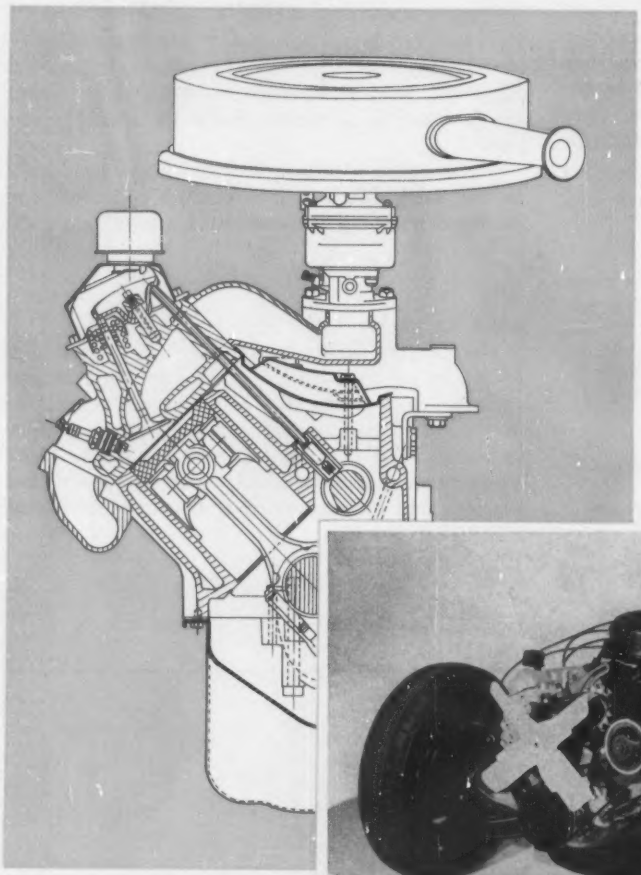
where θ = desired angle, deg. Draw line AB of arbitrary length a. Draw perpendicular BC of length $a \times S$. Line AC is at the desired angle with line BC. This method results in a maximum error of 1 deg, and is especially useful for laying out a large angle,



where a protractor is not sufficiently accurate.—R. P. LANGLOIS, *associate professor, Ecole Polytechnique de Montreal.*

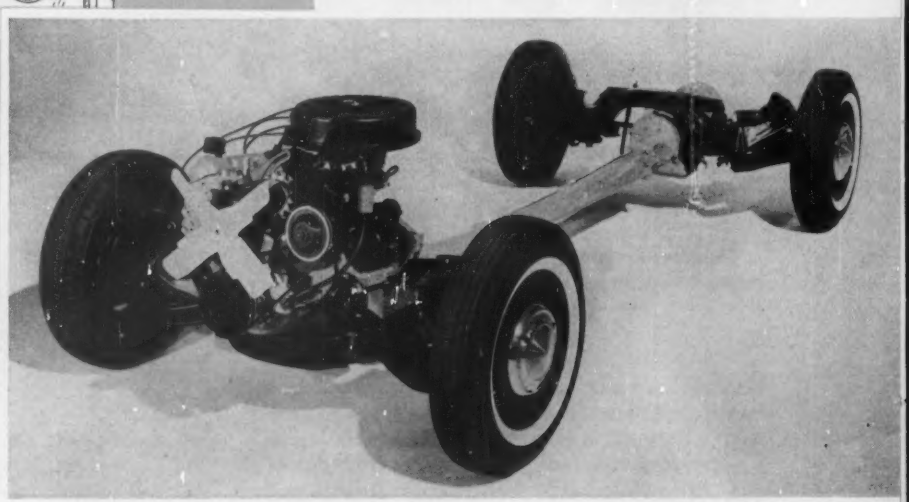
Bent Driveshaft Eliminates Universal Joints





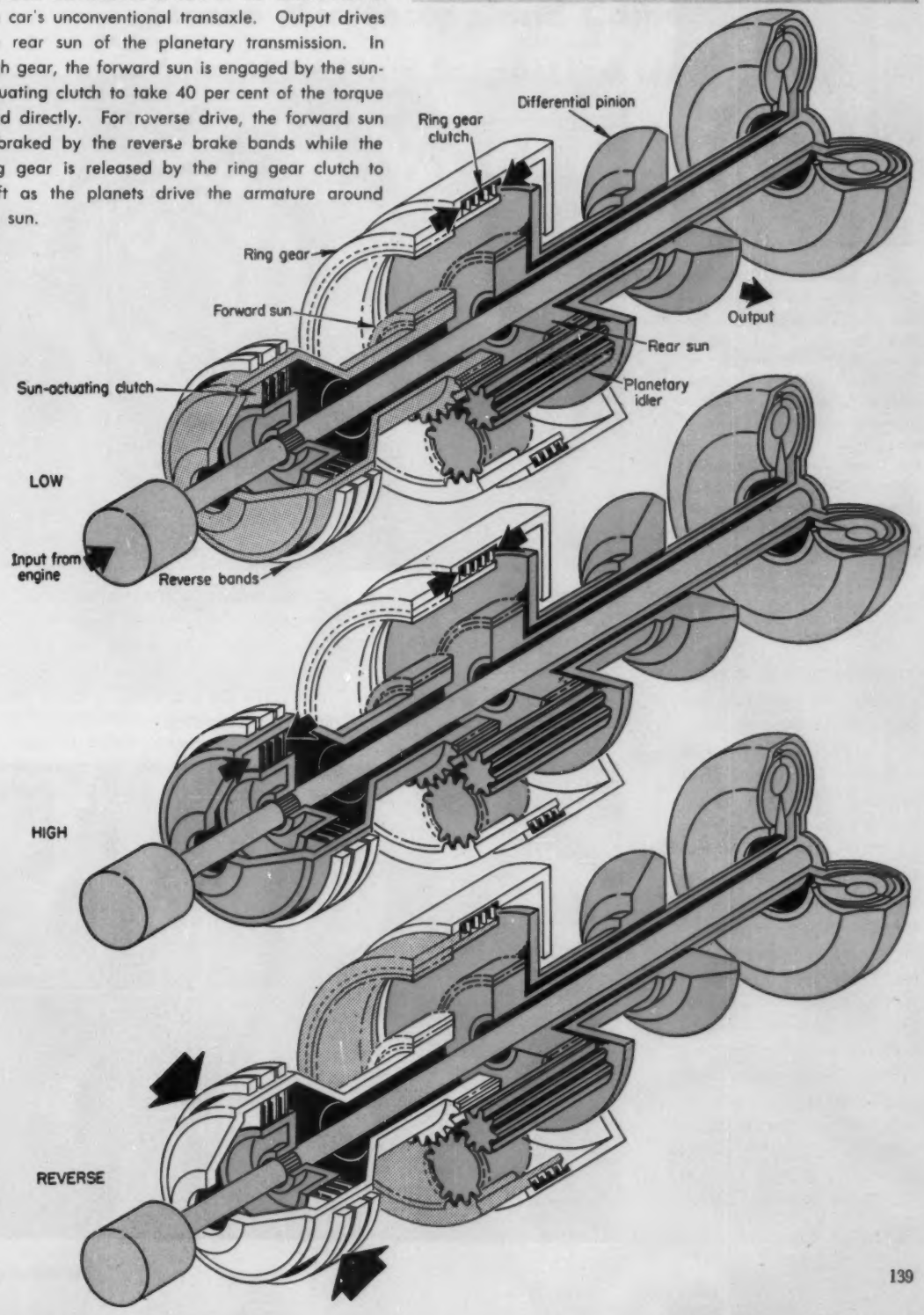
POSSIBLY THE LARGEST flexible drive shaft in operation is the 5/8 in. diam propeller shaft on the 1961 Pontiac Tempest. It does away with the floor tunnel and the universal joint.

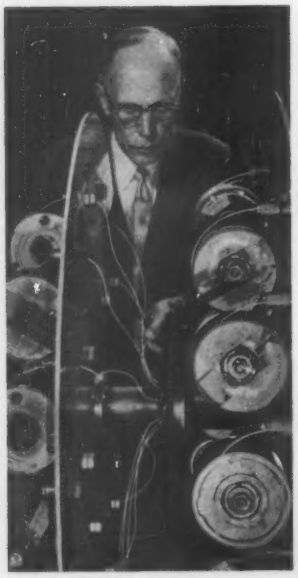
POWER COMES from a canted four-cylinder engine that was designed from one bank of Pontiac's V-8. So little was changed that many parts are interchangeable with the V-8.



In Pontiac Tempest

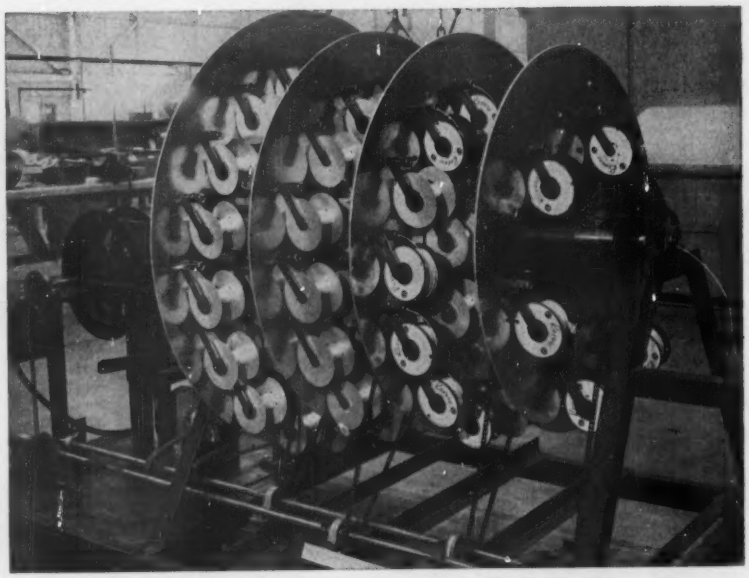
TORQUE CONVERTER IS AFT of the differential in the car's unconventional transaxle. Output drives the rear sun of the planetary transmission. In high gear, the forward sun is engaged by the sun-actuating clutch to take 40 per cent of the torque load directly. For roverse drive, the forward sun is braked by the reverse brake bands while the ring gear is released by the ring gear clutch to drift as the planets drive the armature around the sun.





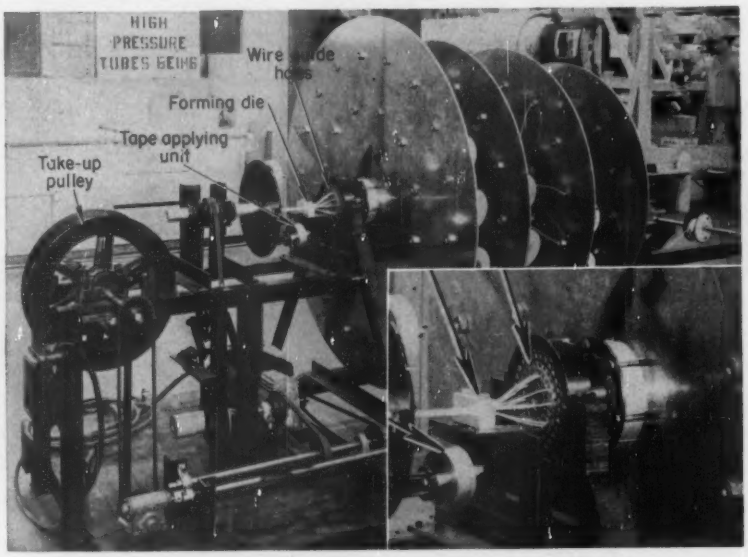
Counter-helical cable winder was developed by two manufacturing research engineers from Boeing's Aero-Space Division, W. L. Dumar Jr. and C. W. Wildebour. Mr. Wildebour (above) holds about 20 patents including one on the automatic gasoline shut-off valve used on the pump hoses at most service stations. The cable-winding machine was first developed to produce electric cable for Bomarc ground launching equipment.

Discs Hold Gimbal-Mounted Spools In Helical Cable Winder

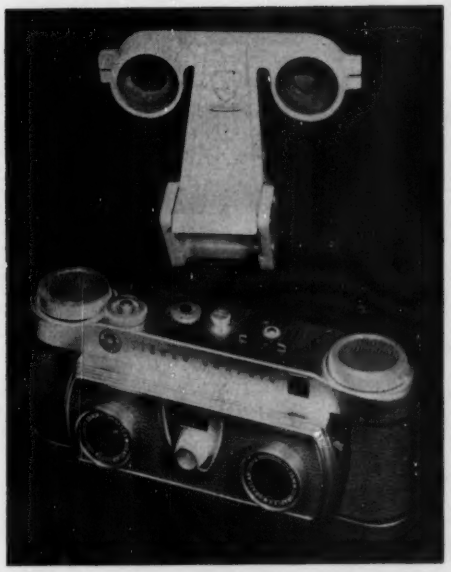


▲ **GIMBAL-MOUNTED WIRE SPOOLS** hang vertical as their winding-disc mount turns in a cable winder. This keeps the wire from twisting as it is wound, so wire in the finished cable has practically no torque stresses induced by winding.

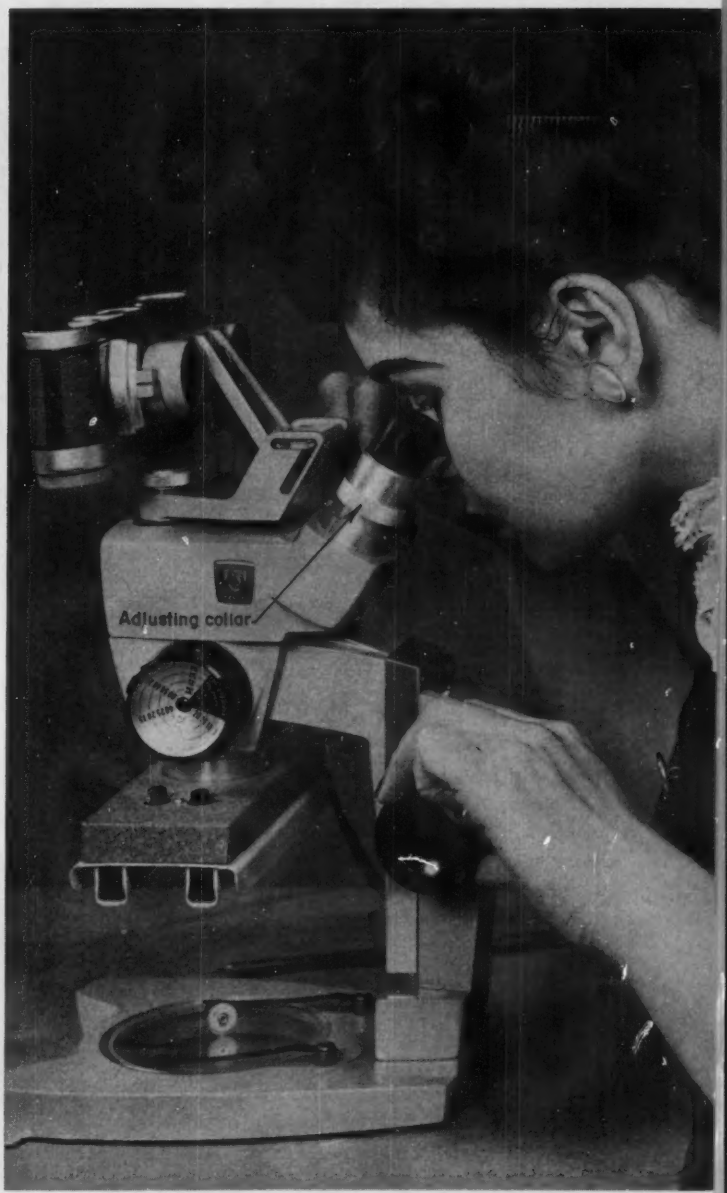
COUNTER-ROTATING DISCS wind up to 84 wires in four layers of contra-helical lay—that is, each layer is wound in a direction opposite to its neighbor. Each aluminum disc is independently driven by chain from one of two counter-rotating shafts. The shafts also drive a tape applying unit and a take-up pulley. Ratio of take-up pulley speed to winding-disc speed is planned through gear ratios to produce the optimum helical path. One motor powers the unit. Each of the nesting disc shafts except the smallest is perforated by a circle of axially running ¼-in. holes to conduct wires from the preceding disc to the forming die. Core wire passes through the center of the smallest shaft.



Stereo Microscope and Camera Joined in New Inspection Unit

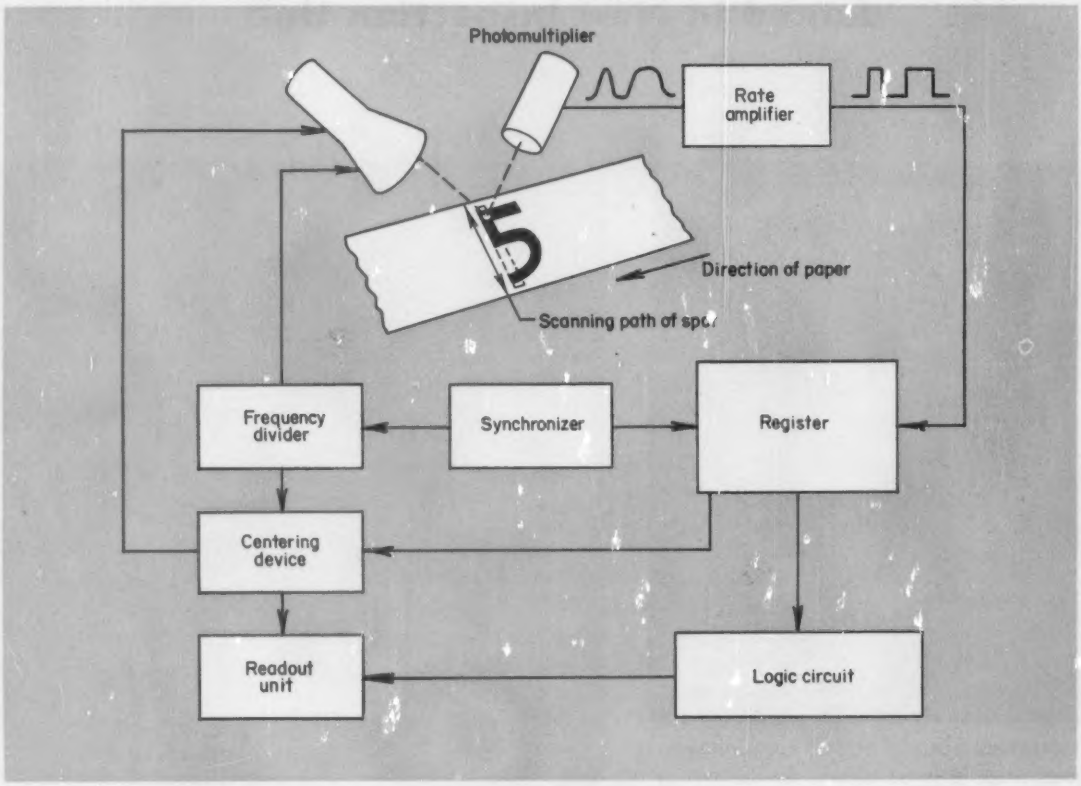


MOUNTING BRACKET HOUSES auxiliary lenses that adapt a stereo camera for use with a stereo microscope. Each lens has an element designed to make the camera "parafocal" (that is, in this case, interchangeable with the human eye), and a prism that redirects the line of image propagation.

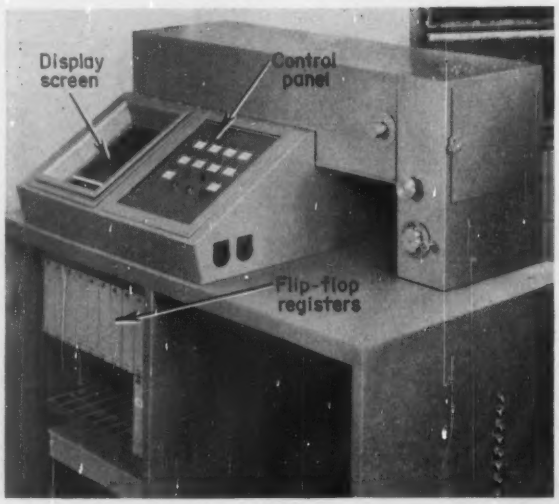


ADJUSTING COLLAR SHARPENS focus on left eyepiece of the microscope. The instrument is focused using the right eye (dominant for most people). Then accommodation for the left eye is made with the collar. For use with the stereo camera that has two identical "eyes," the operator shifts his right eye to the left eyepiece and readjusts it to sharp focus. Camera is a Graflex Stereo Graphic. Mounting bracket and Cycloptic Stereoscopic Microscope are manufactured by American Optical Co.

Cathode-Ray Tube Teams With Photomultiplier To Scan Printed Symbols



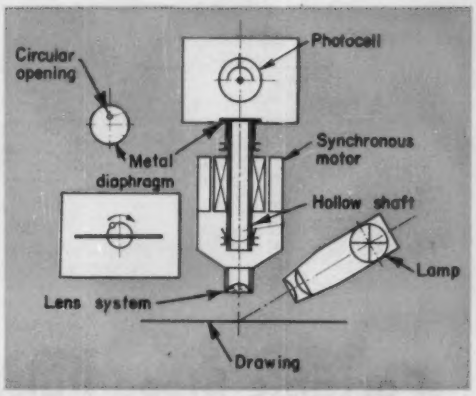
AN OSCILLATING SPOT of light is thrown by a cathode-ray tube onto a printed character in a mechanical reading unit. Material being read moves through the reading position in a direction perpendicular to the oscillation of the light spot. The result is that the whole surface of the reading matter is scanned by the light spot. A photomultiplier takes a continuous reading of light intensity reflected from the paper. This is correlated in a computer with paper and scanning-spot position to recognize the character.



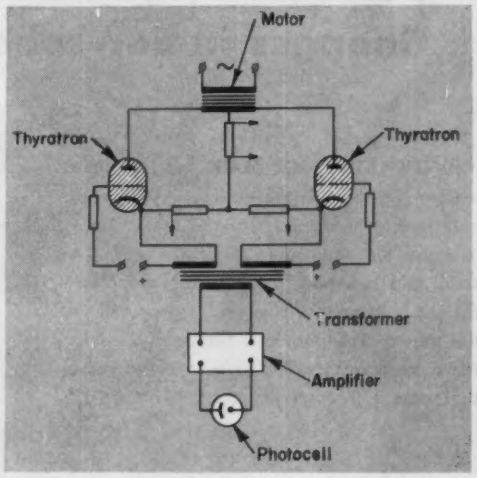
AUTOMATIC READING UNIT is used in check readers at banks. Output may be used to produce a visual reproduction of the figure, to make a punched tape record, or a printed symbol. The unit is designed by Standard Electric Lorenz AG, Stuttgart, Germany.

Revolving Aperture Reads Line Slope To Guide Copy Miller

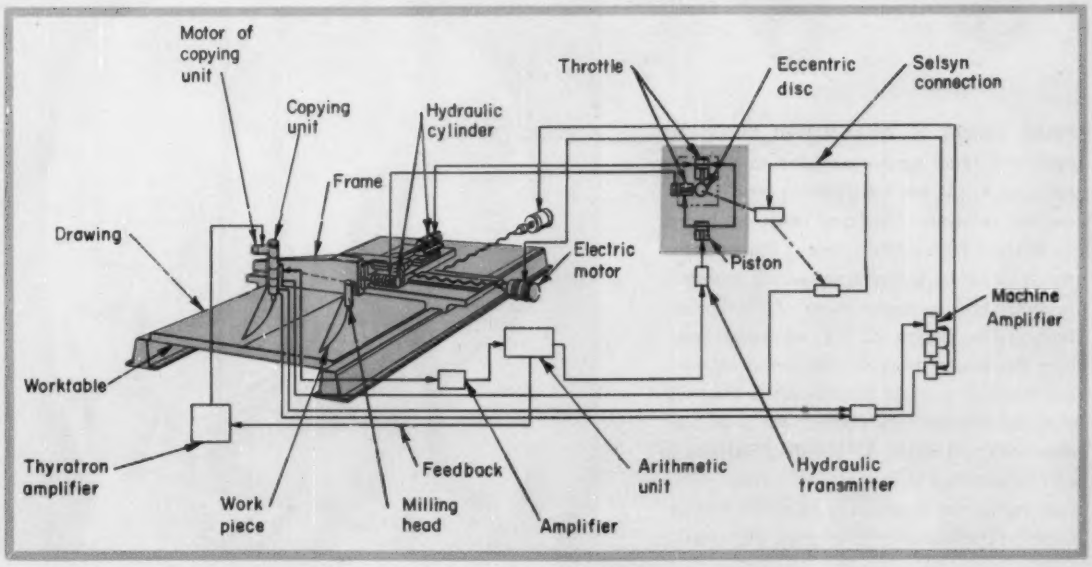
PULSE SIGNALS GENERATED by a revolving aperture give slope and location of a pattern line in a copy miller. The aperture is located in a diaphragm in the bottom of a tracing head. In operation the diaphragm is rotated and the eccentric aperture describes a small circle. Light reflected from the tracing surface passes through the aperture and strikes a photoelectric cell. When the aperture swings across a traced line, transmitted light diminishes to cause a pulse in the photocell output.

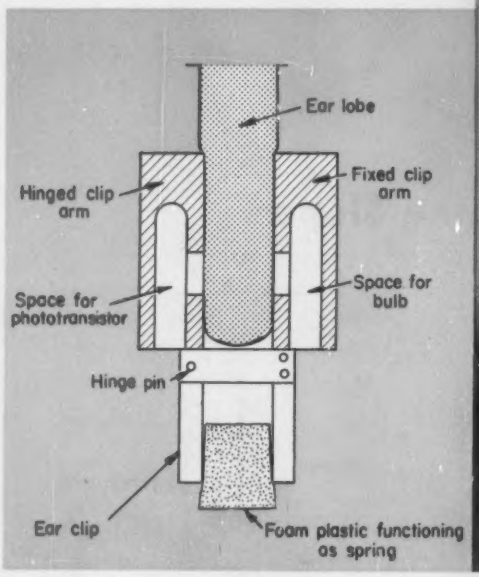


THYRATRONS CORRELATE photocell pulses with angular position of the aperture. Plate voltages are synchronized with rotor speed, so if the aperture crosses a line twice in a revolution, each tube will fire once. Slope of the line and tracer deviation are functions of plate voltage at the time of firing.



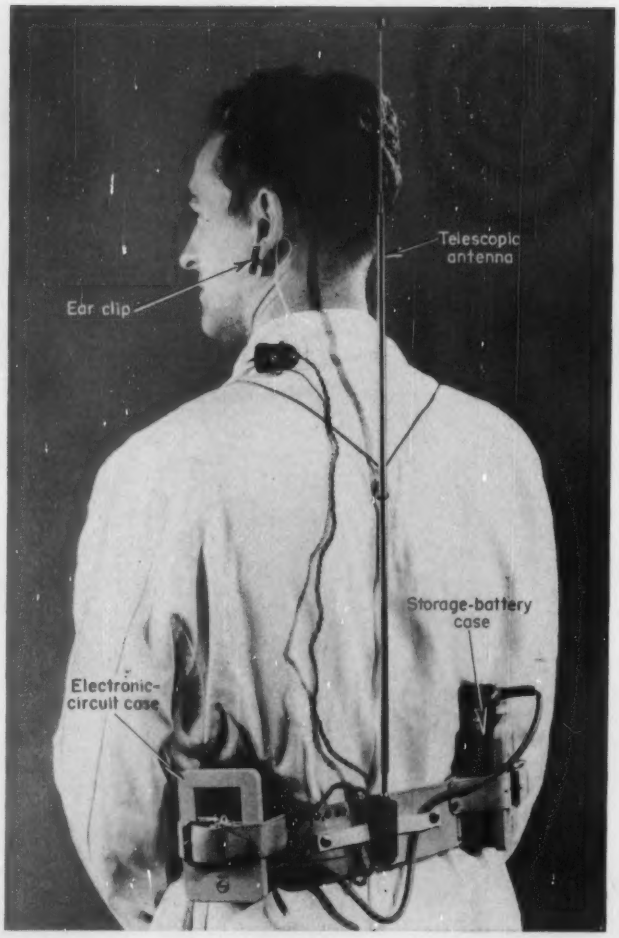
THYRATRON OUTPUT is used to control hydraulic cylinders. Selsyn-operated throttles control relative speed of x and y components for proper slope. Sum of signals forms feedback to control the motor of the copying unit. The copy miller is described in **Stanki i instrument** magazine, Moscow.





Portable Blood Pulse Meter Reads Changes in Ear-Lobe Color

PHOTOSENSITIVE CELL READS level of light transmitted through the earlobe. With each heartbeat, the blood stream momentarily changes the light density of the ear. A small clip fastened to the subject's ear has a light bulb on one side and a photocell on the other. The photocell transmits an electric pulse corresponding to each blood pulse that passes through the ear.



PULSE SIGNAL IS TRANSMITTED through a miniature radio sender strapped to the subject's back. It can be detected by a standard AM receiver. The heart beats are heard as a short high-pitched note. The apparatus is used in human-engineering research to study energy consumption of the human body. The design of the equipment permits the subject to move about and do various forms of work or exercise while resulting changes in pulse are noted. For a permanent record, a standard recording instrument can be attached to the receiver. Pulse meter and transmitter were designed by NV Philips' Gloeilampenfabrieken Eindhoven, Holland.

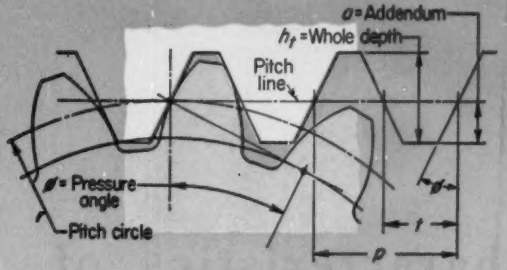


Fig. 1—Tooth proportions on standard rack and pinion.

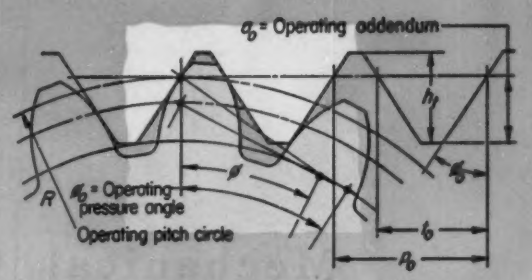


Fig. 2—Modified tooth proportions on rack for mesh with pinion of standard tooth proportions.

Rack Teeth for Exact Stroke

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General Engineering Dept.
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SOMETIMES a spur pinion-and-rack combination is desired in which the rack is displaced an exact stroke while the pinion rotates through a specified angle. This condition is readily accommodated by changing the pressure angle and tooth thickness of the rack teeth for mesh with a standard pinion. A typical problem is presented here to demonstrate the method.

EXAMPLE: Suppose a rack stroke of 48.000 in. is required for a driving-pinion rotation of exactly one revolution. The pinion is to have AGMA standard tooth proportions for involute spur gears. Specifically, it is to have a pressure angle $\phi = 20$-deg, a working depth $h_k = 2.000/P$, a circular tooth thickness $t = \pi/2P$ without backlash, and a diametral pitch $P = 2$.

The arc relationship of the linear displacement S of the rack to the operating pitch radius R of the pinion and the angle α through which the pinion rotates is expressed by

$$S = R\alpha \tag{1}$$

Fig. 1 illustrates a standard pinion of pitch radius r in mesh with a standard rack. Fig. 2 shows the same pinion in contact with a modified rack at operating pitch radius R and operating pressure angle ϕ_o.

When Equation 1 is applied to the example,

$$R = \frac{48.000}{2\pi} = 7.6394$$

is established as the necessary operating pitch radius. It lies between the pitch radii $r = 7.5000$ and 7.7500 on standard pinions with $N = 30$ and 31 teeth, respectively. Either may be used; the former is chosen here.

If p_o is the operating circular pitch,

$$p_o = \frac{S}{N} \tag{2}$$
$$= \frac{48.000}{30} = 1.6000$$

Thus, the operating pressure angle, ϕ_o, is found by

$$\cos \phi_o = \frac{p \cos \phi}{p_o} \tag{3}$$
$$= \frac{\frac{\pi}{2}(0.93969)}{1.6000} = 0.92254$$

where p is the circular pitch.

For the example, $\phi_o = 22.70$ deg, which is the pressure angle required for the rack.

The operating addendum of the rack teeth is found from

$$a_o = R - r + \frac{1}{P} \tag{4}$$
$$= 7.6394 - 7.5000 + 0.5000$$
$$= 0.6394$$

The tooth thickness of the rack at the operating addendum depth is

$$t_o = p_o - 2R\left(\frac{t}{2r} + \text{inv}\,\phi^* - \text{inv}\,\phi_o\right) \tag{5}$$
$$= 1.6000 - 15.2788\left(\frac{0.7854}{15.0000} + 0.0149 - 0.0221\right)$$
$$= 0.9094$$

where inv ϕ^* and inv ϕ_o are the involute functions at the standard and operating pressure angles, respectively. Backlash can be provided by reducing the calculated thickness as desired.

*ASME Handbook—"Engineering Tables," McGraw-Hill Book Co. Inc., New York, 1956, p. 3-26.

Mechanical Characteristics of

ELASTOM

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Consultant
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ELASTOMERS are divided by use into two general categories. The first includes applications in which the material absorbs impact, stores energy, or isolates motion, vibration, or sound. The second group consists of elastomers that serve as containers, covers, seals, or guiding surfaces. This article discusses the first category—mechanical applications—and presents over-all characteristics of the materials and design guides for their use.

Characteristics

Elastomers—rubber-like materials—have value in mechanical applications because of their ability to: 1. Store and return large amounts of energy. 2. Damp energy flow. 3. Be formed into almost any shape. 4. Be bonded to metals.

In general, elastomers have high molecular weight and consist of long-chain molecules that are kinked or twisted in their free state and tend to straighten out when deformed.

Hardness: Resistance to distortion is made up of two components: 1. Elastic or resilient resistance. 2. Resistance caused by hysteresis.

Soft stocks—approaching 30 Shore durometer—usually contain so much oil that they sacrifice other properties; hard stocks—above 65 durometer—may contain so much loading with pigments such as carbon black that other properties are also compromised.

Resilience, which can be considered quantitatively or qualitatively, is the measure of a material's ability to deform under load, store energy, then assume its original shape and return the stored energy.

Quantitatively, elastomers can store up to 80,000 in.-lb per lb for instantaneous loads under extreme conditions, although 20,000 in.-lb per lb for instantaneous loads and 4000 in.-lb per lb for sustained static loads are rough working limits.

Qualitatively, shear modulus of elasticity is a

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ERS

measure of resilience in elastomeric materials. Values vary in the range of 40 to 200 psi or more at 80 F. Since the stress-strain curve, Fig. 1, is not a straight line, no definite static modulus exists in the true sense. For convenience, therefore, the slope is read at 150 per cent shear.

The slope of the dynamic modulus curve of an elastomer is greater than the static modulus, Fig. 2. Static data of Fig. 1 and 2 are based on 0.01 cps; dynamic data, on 2 cps. Above 20 cps, the modulus increases gradually, and below 0.01 cps the modulus appears to diminish. However, low-frequency data are influenced by creep, and high-frequency data may be misinterpreted because of a standing-wave or inertia effect within the body of the elastomer. In general, dynamic characteristics in the working area of 1 to 20 cps do not change greatly. Higher frequencies are influenced by several variables not covered in this article. Further information on higher frequencies is available through the *Bibliography*.

Most elastomers are stiff during the first flexures, and data should be based on tests after at least five flexures in the required range.

Temperature: Most elastomers function best at about 80 F. They soften slightly at elevated temperatures and have an upper operational limit approaching 200 F (except for special high-temperature compounds). High-temperature operation reduces life significantly and causes greater creep.

At low temperatures—particularly below zero F—the compounds stiffen rapidly, and they become brittle at −20 to −65 F unless specially compounded. Quantitatively, the modulus of most compounds is reduced about 10 per cent when heated from 80 to 200 F and is increased by 300 per cent or

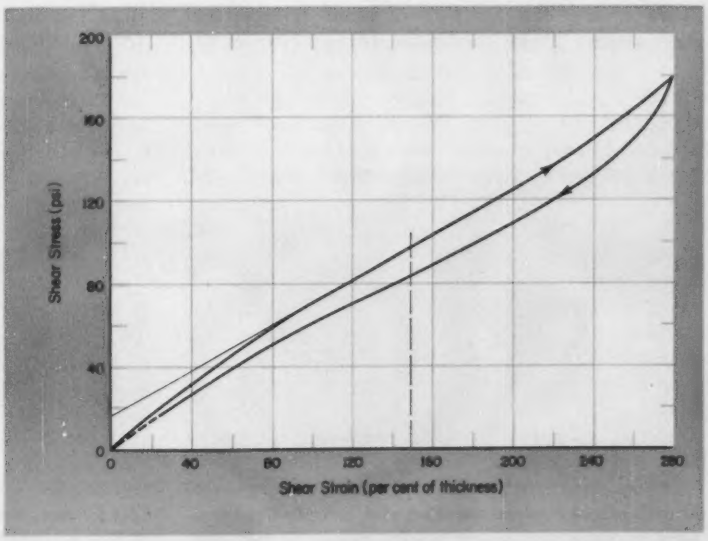


Fig. 1—Slope of a stress-strain curve for elastomeric materials is read at 150 per cent shear. Curves shown are for static shear of a 40 durometer reference stock at 80 F. Shear modulus is 54.

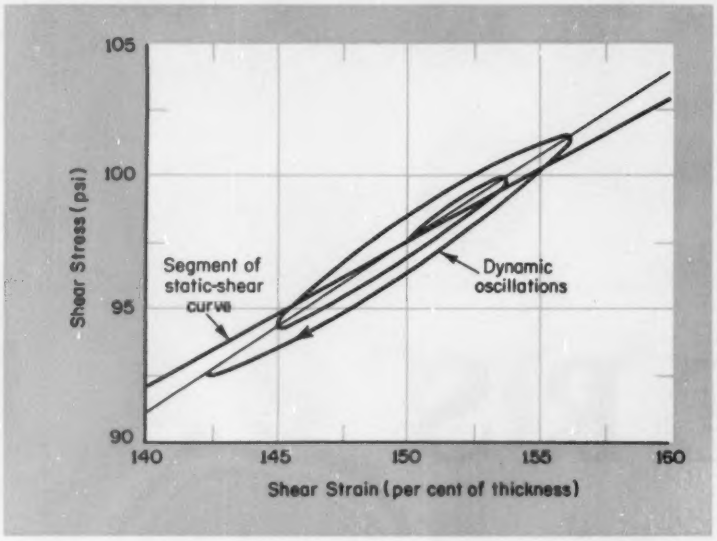


Fig. 2—Slope of approximate major axis of dynamic-flexure loops shows increase of dynamic modulus over static modulus for 40 durometer stock at 80 F.

more when cooled from 80 F to the lower range of −20 to −65 F. Special compounds offer as little as 150 per cent change in modulus from −65 to 300 F, although other properties are sacrificed.

Changes in physical properties with reduced temperature are not completely reversible for some synthetics. Returning to room temperature may leave them stiff, and a short, high-temperature exposure may be necessary to restore normal characteristics.

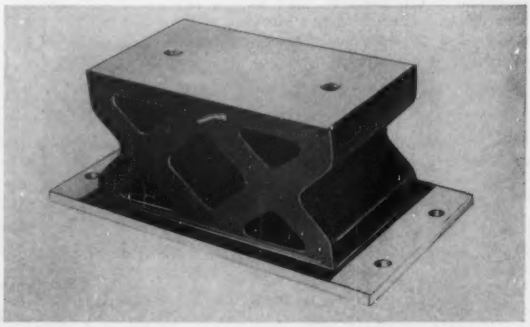
Stress Limits: Working stress can be measured by mean stress and stress range. Both compressive and tensile stress depend on the escape or bulge area. Maximum permissible compression may go well above 1000 psi. Mean shear stress may vary from less than 25 psi for machine mountings to over 200 psi for special suspension applications. In general, permissible stress increases with modulus.

Stress range has a much greater effect than mean stress on fatigue life, and in no case should the range reverse the direction of stress or approach zero stress. These conditions reduce fatigue life appreciably. Since all stress-strain curves for elastomers show increased moduli at very high stresses, optimum upper limits exist, regardless of any life requirements, beyond which any increase in static stress may result in requiring a larger rather than a smaller volume of elastomer.

Fatigue Life: If stress frequency is high enough to produce internal heating because of hysteresis, fatigue life of elastomeric parts is reduced. A rough measure of probable fatigue life is work done, either in supporting a static load or in storing and returning energy throughout the life of the part.

Areas of concentrated work in a part should be avoided. Assuming no serious concentration, unit work done in supporting a static load can vary from 10 to 100 in.-lb per lb of elastomer for machine or engine mountings, and can go as high as 1000 in.-lb or more per lb for such uses as flexible wheel suspensions for vehicles. Even at the latter loading, tests and field operations showed more than 1 billion in.-lb of energy flow per cubic inch (or 25 billion in.-lb per lb) as a reasonable fatigue

Aircraft-antenna mount provides seal and absorbs vibrations in application where rigidity cannot be tolerated.



Cored holes provide low-frequency and high-amplitude motion in heavy-machinery mount.

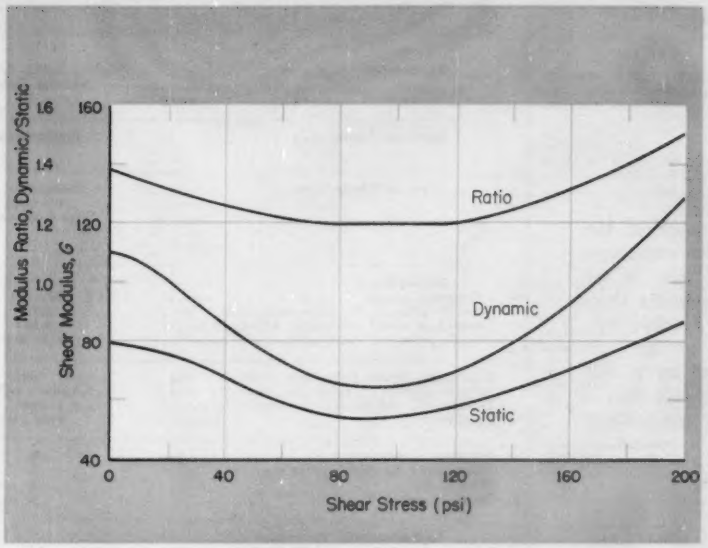


Fig. 3—Dynamic and static shear stress versus shear modulus, *G*, for 40 durometer stock. Top curve represents ratio of dynamic-to-static modulus.

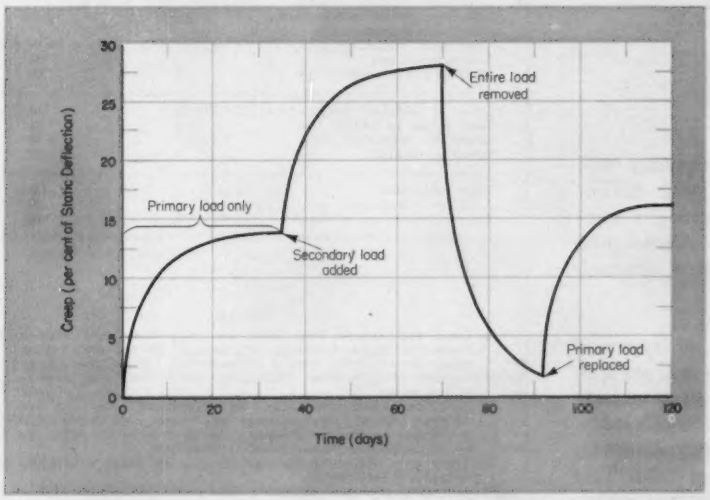


Fig. 4—Typical creep characteristics of 40 durometer reference stock at 80 F.

life for a stress range of ±20 psi and 125 psi mean static shear. Reduction of life with increased range is exponential, and at the other extreme, a mounting stressed at ±320 psi (reversing) in shear averaged only 500,000 in.-lb per cu in. fatigue life. As a rough guide, fatigue life may be assumed to be reduced by 50 per cent for every 20 F rise in stock temperature above 80 F unless specially compounded.

Creep: Failure to return to the precise original form after distortion is an inherent characteristic of all elastomers. The return loop of Fig. 1 is exaggerated to show this characteristic.

At 80 F, creep for the entire life of a part may amount to as little as 15 per cent of static deflection for high-grade, highly resilient stock used in a relatively small cyclic-stress range. Any increase of internal temperature due to hysteresis or of ambient temperature causes a marked increase in creep, and parts used under adverse conditions can creep as much as 200 per cent of static deflection.

For high-grade resilient compounds not particularly formulated for low creep, creep doubles for each 20 F increase above 80 F. In general, a tightly cured natural or synthetic stock is highly resilient and affords low creep and low hysteresis characteristics. A stock that has high hysteresis characteristics generally also exhibits high creep.

When a part is loaded, then unloaded, a portion of the creep will disappear within a few hours, Fig. 4. The unrecovered creep is referred to as permanent set. Since most creep occurs rapidly when a load is first applied, it can usually be allowed for in positioning the parts. Or, a heat cycle can be used to remove much of the creep in a given direction.

Creep should not be confused with the Joule effect. Static deflection of all high-polymer elastomers is greater when their temperature is reduced.

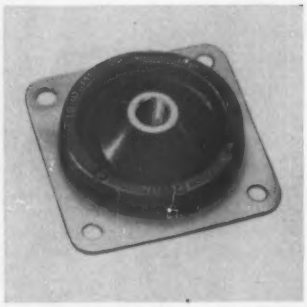


Plate mounting, top, with wide radial section is used to isolate moderate shock loads. Flexible coupling, bottom, can be used as a hub, foot, or mounting to take compression, shear, or torsion.

A mass supported by a rubber-like polymer will actually sag, increasing its nominal static deflection by approximately 15 per cent during a temperature change from 80 to −20 F. Above 80 F and below −20 F, the change is more gradual. This change is completely reversible.

Hysteresis: Elastomers vary widely in hysteresis or damping characteristics. In a selected working range, a tightly cured elastomer may store and return energy at more than 95 per cent efficiency. Other elastomers, compounded for high damping, have efficiencies of the order of 30 per cent. This resilience, or the corresponding energy loss which is a measure of hysteresis, is related to the change in energy in the cycle and not directly to the total energy stored from the free position.

As temperature drops, total hysteresis increases because of the effects of viscosity and crystallinity. The increase in hysteresis may be well over 300 per cent, particularly if the stock is held at the low temperature for a long period.

Both modulus and hysteresis diminish rapidly with flexure at low temperature, not only because of the breaking up or diminishing of the crystalline structure, but also because of heat from the high hysteresis. Special compounding of either a natural rubber or a synthetic compound can improve these characteristics, and compounds are available that afford less than 150 per cent increase in hysteresis from −65 to 300 F. Such extreme stability is necessarily obtained through the loss of some other characteristics, but satisfactory compromises can be made.

Bonding: To allow a high degree of freedom in one or more modes of motion and restrict motion

Elastomer[2]	NR, Natural Rubber
Common Name	Crude rubber
Type or Trade Name	Smoked sheet, pale crepe, flat bark crepe
Properties	
Durometer range	30-100
Specific gravity of base elastomer	0.93
Density of base elastomer (lb/cu-in.)	0.033
Tensile strength, pure gum (psi)	Over 3000
Elongation, pure gum (per cent)	750
Tensile strength, reinforced (psi)	Over 4000
Elongation, reinforced (per cent)	500
Resilience	Very high
Electrical resistivity	E
Bondability to rigid materials	E
Workability	E
Ease of cure	E
Environmental Resistance	
Tensile strength at 250 F[5] (psi)	2500
Elongation at 250 F[5] (per cent)	500
Tensile strength at 400 F[6] (psi)	125
Elongation at 400 F[6] (per cent)	80
Low-temperature brittle point[7] (F)	−80
Low temperature range of rapid stiffening (F)	−20 to −50
Compression set	G
Drift at room temperature	G
Drift at elevated temperature (150-212 F)	G
Heat aging at 212 F	G
Oxidation resistance	G
Ozone resistance	P
Tear resistance	G
Abrasion resistance	E
Impact resistance (fatigue)	G

NOTES

1. Data recorded is that most generally associated with various elastomer types described. Significant change can be made in many instances by special compounding. To achieve an optimum balance of properties, production compounds may deviate from values given.
2. Bold face capitalized letters by themselves (NR, IIR, etc.) are official ASTM designations for these materials (ASTM—Standards on Rubber Products Designation D1418-58T). To date, not all elastomers have been so classified.
3. These are the more common grades or types available. Some names are proprietary.
4. Generally require extensive post-cure, sometimes for several days.
5. Values are subject to the balance required with other properties. Samples are aged at this temperature just long enough to attain ambient.
6. Samples are aged eight hours before being tested at this temperature. Eight hours is not normally long enough for aging to become a factor, however, most elastomers except silicones and fluoroelastomers degrade rapidly at this temperature.
7. This is the temperature at which the sample, being deformed at a constant rate, breaks. See also "Low Temperature Range of Rapid Stiffening."

Natural Rubber

NR is obtained from the Hevea Brasiliensis tree grown principally in the Far East. It is a high molecular-weight material composed of many isoprene units or monomers joined together to make a polymer, in this case a natural-rubber molecule. It is used in high-performance applications unless prohibiting environmental conditions exist.

Isobutylene Isoprene Rubber

IIR is a high molecular-weight copolymer of many units of isobutylene and a few of isoprene. Structurally, it has a low active chemical "status" for cross linking, which makes it relatively inert chemically and difficult to bond. Its chemical inertness qualifies IIR for applications that require resistance to weather, ozone, heat, chemicals, and solvents.

Properties of Elastomers[1]

IIR, Isobutylene Isoprene Rubber	NBR, Nitrile Butadiene Rubber	CR, Chloroprene Rubber	Silicone Rubber	Organic Polysulfide Rubber	Urethane Elastomers	Chloro-sulfonated Polyethylene	Fluorinated Elastomers	SBR, Styrene Butadiene Rubber
Butyl or GR-1	Buna N	Neoprene or GR-M		Thiokol or GR-P				Buna S or GR-S
Enjay	Chemigum, Butaprene, Paracril, Polysar, Hycar, Krynac	GNA, GRT, WRT	Silastic	ST, FA	Thiokolthane, Multrathane, Chemigum SL, Neothane, Genthane, Adiprene	Hypalon, Hypalon 20	Fluorel, Kel-F, Viton	Philprene, Naugapol, Synpol, Copo
40-75	20-100	40-95	45-60	20-80	55-100	45-95	55-90	40-100
0.92	1.00	1.23	1.25	1.34	1.05	1.10	1.4-1.85	0.94
0.033	0.035	0.044	0.045	0.048	0.039	0.040	0.051-0.067	0.034
Over 1500	Under 1000	Over 2500	Under 400	Under 500	To 7000	Over 2000	600-2500	Under 1000
Over 1000	800	850-1000	Under 200	Under 200	500	700	100-250	700
Over 2000	1000-3500	Over 3000	600-1500	500-1500	...	Over 2000	1000-2500	Over 2000
Under 800	200-600	650-850	200-800	200-350	...	Under 500	100-350	450
Low	Medium	High	Low to medium	Very low	Medium to high	Medium	Low to medium	Medium
E	F	F	E	F	G	G	G	E
F-G	G-E	G-E	F-G	F	F-G	F-G	P-G	E
G	G	G	F-G	F	F	F-G	P-F	G
G	G	G	F-G[4]	F	E	G	F-G[4]	E
1000	700	1500	850	700	1800	500	300-800	1200
250	120	320	350	140	250	60	100-350	250
350	130	180	400	Under 25	200	200	150-300	170
80	20	10	200	Under 25	140	20	50-160	60
−80	−65	−45	−90 to −200	−60	−60	−80	+10 to −60	−80
0 to −20	+30 to −20	+10 to −20	−60 to −120	−15	−10 to −30	−30 to −50	+20 to −30	0 to −50
F	G	F-G	G-E	P	E	F-G	G-E	G
F	G	F	P-E	P	G-E	F	G	G
F	G	F-G	E	P	E	F-G	G-E	G
G	G	G	E	G	F	G	E	G
G-E	F-G	G	E	E	E	E	E	G
E	P	E	E	E	E	E	E	P
G	F	G	P-G	P	E	F-G	P-G	F
G	E	G-E	P-G	P	E	G-E	G	E
F	F	G	P	P	G	F-G	P-G	G

E=Excellent; G=Good; F=Fair; P=Poor

Nitrile Butadiene Rubber

NBR elastomers are copolymers of butadiene and acrylonitrile monomers. They have exceptional oil resistance, with resistance increasing and low-temperature flexibility decreasing as percentage of the acrylonitrile monomer is increased. Like SBR, they have poor gum or unreinforced strength. They are used effectively with synthetic lubricants of the diester type.

Chloroprene Rubber

CR elastomers are polymers of chloroprene monomers. They exhibit moderate oil resistance and are generally the most rubber-like (resilient) of all synthetics. They are flame resistant and relatively inert chemically. They are applied where oil, ozone, heat, and weathering are present. Low-temperature flexibility is poorer than natural rubber.

Silicone Rubber

Silicone elastomers are chains of inorganic materials composed of silicon and oxygen. Over a wide temperature range they are the most stable synthetics available. Six general types in common use are: 1. General purpose. 2. Extreme low temperature. 3. Extreme high temperature. 4. Low compression set—low shrink. 5. High strength—broad temperature. 6. Fluid resistant.

Organic Polysulfide Rubber

Polysulfide elastomers are polymers of principal importance for their high solvent resistance, good aging characteristics, and low permeability. Poor plastic flow and generally low physical properties limit their wide application.

Urethane Elastomers

Urethanes are reaction products of diisocyanate. Through close control of chemicals reacted with these diisocyanates, elastomers formed exhibit unusual ranges of mechanical and structural properties—extreme abrasion resistance, high durometer, high extensibility, and high tensile strength.

Chlorosulfonated Polyethylene

Hypalon is made by reacting polyethylene with sulfur dioxide and chlorine. Although available chemical sites are present to allow cross linking or vulcanization, only a few materials will bring about a reaction. Hypalon is outstanding in its resistance to ozone, heat, oxidation, and weathering.

Fluorinated Elastomers

Fluoroelastomers are copolymers of molecules containing carbon and fluorine. They are characterized by their resistance to chemical and other deteriorating fluids and to temperature extremes. Mechanical properties are comparable to those of other synthetic rubbers—generally between silicones and neoprenes.

Styrene Butadiene Rubber

SBR consists of synthetic copolymers of styrene and butadiene monomers joined into single huge molecules. SBR resembles natural rubber in most respects but is lower in cost. It has poor gum strength and less resilience than natural rubber.

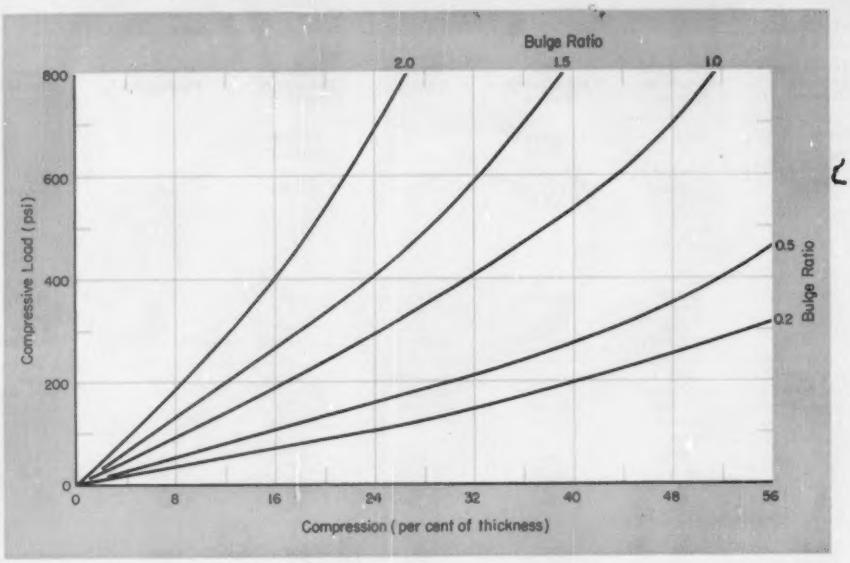


Fig. 5 — Compression versus unit load for several bulge ratios. Stock is 40 durometer.

in other modes, elastomers are often bonded to metal or other rigid components. The ability of various elastomers to form a good bond is shown in *Properties of Elastomers*.

Environment: Resistance to sunlight or ozone can be improved either by special compounding or by application of protective surface coatings. Resistance to various chemicals can be improved by the same general techniques.

Stress Analysis

Assuming a simple and uniform section, load-supporting area can be divided by area of exposed surface or bulge area to obtain a "bulge ratio," Fig. 5. In general, samples having the same bulge ratio will deflect the same per cent of their thickness under the same unit compressive load.

Shear strain in an elastomer can be analyzed and

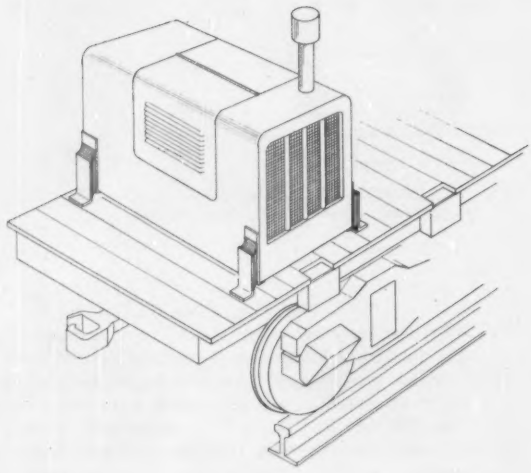


Fig. 6

DESIGN

Problem

A missile ground-support railroad car carries a motor-generator-compressor unit, Fig. 6, weighing 4000 lb. The unit is to be supported by four sandwich-type mountings so that the mountings are in shear vertically and will take fore and aft humping forces in compression. The assembly has a lowest harmonic forced excitation of 860 cpm vertically and negligible horizontal excitation.

Although external disturbing forces such as vertical impact and horizontal humping are often involved in this type of application, for simplicity, this problem considers only static deflection and vibratory forces in the vertical direction.

Transmissibility is to be 20 per cent; that is, 80 per cent of the disturbing vibratory force must be absorbed by the mounting. A manufacturing tolerance of ±10 per cent in elastic rate is allowed.

Solution

From a standard transmissibility curve, Fig. 7, the desired 20 per cent transmissibility shows a required ratio of f/f_n of 2.5, where f = impressed frequency; and f_n = natural frequency. From this relationship, $f_n = 860/2.5$, or 344 cpm, the required natural frequency.

An elastically supported mass behaves approximately like a pendulum, and the nominal dynamic deflection,

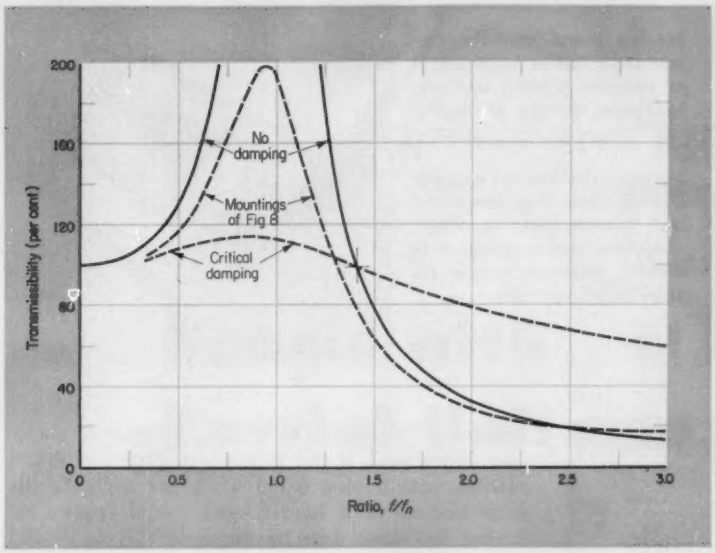


Fig. 7—Transmissibility curve.

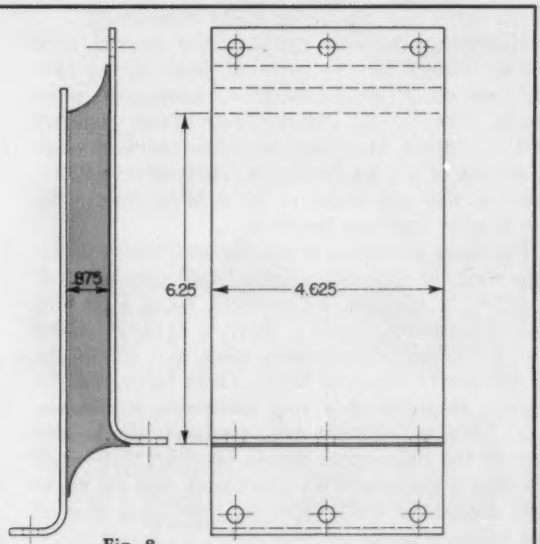


Fig. 8

computed easier than compression and extension. However, the sample should have a size ratio of direction of shear to thickness of at least 5:1—preferably 10:1 or more—to avoid bending instead of the intended deforming in shear.

Although it is necessary to classify the type of distortion in test samples, working deformations in actual applications are frequently a combination of shear and compression (and possibly tension also) varying throughout the piece. The penalty for concentrated strain may not be as severe as in steel, but nevertheless concentrated strain should be avoided when possible.

An estimate of probable life is based on the elements being subjected: 1. To the greatest deformation. 2. To the greatest amount of energy flow. These two elements may not be identical. For example, a part could have high-frequency, small-amplitude movements in one direction and large-amplitude movements at a lower frequency in an-

EXAMPLE

d, is found from the equation $d = (188/f)^2$. From this relationship, $d = 0.298$ in.

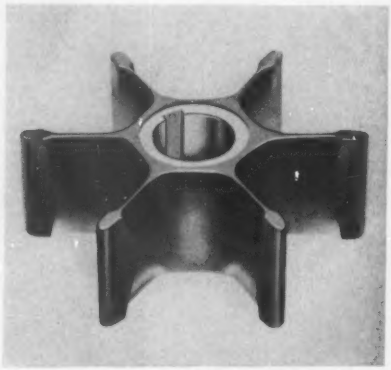
Dividing the weight of the unit by d gives the required dynamic rate for the mountings: $4000/0.298 = 13{,}440$ lb per in.

For ease of calculating, a 40-durometer stock is used as a trial material. For this material and the service involved, a static shear stress of 35 psi is in the practical range.

From Fig. 3, at 35 psi stress, the dynamic modulus is found to be 90. Since the modulus, G, is a measure of stress divided by strain, the dynamic strain in the sandwich is $35/90 = 0.389$ or 38.9 per cent of the thickness. Therefore, the estimated thickness is $0.298/0.389 = 0.766$ in. Allowing for the 10 per cent manufacturing tolerance, an actual sandwich thickness of 0.850 in. would be acceptable.

To determine static deflection, Fig. 1 shows that, at 35 psi, deflection would be 45 per cent of thickness or 0.383 in. Allowing 10 per cent for early creep, estimated static deflection (to determine assembled height) would be 0.422 in.

Required area of each mount is found by dividing the weight of the unit by the static shear stress and by the number of mounts. Thus, $4000/35(4) = 28.5$ sq in. Fig. 8 shows a typical mount for this application.



Bonded pump impeller can operate in either a concentric or eccentric housing and can be flexed radially or axially.

Standard-construction bonded-channel mountings are available in wide capacity ranges. Mountings can be designed to provide different motion resistance in each direction.

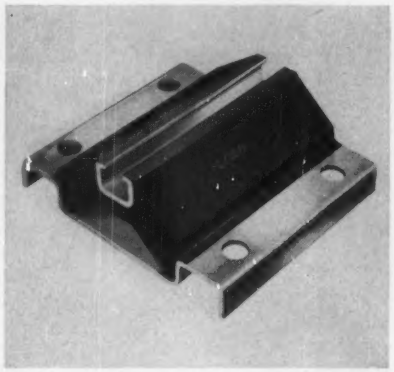
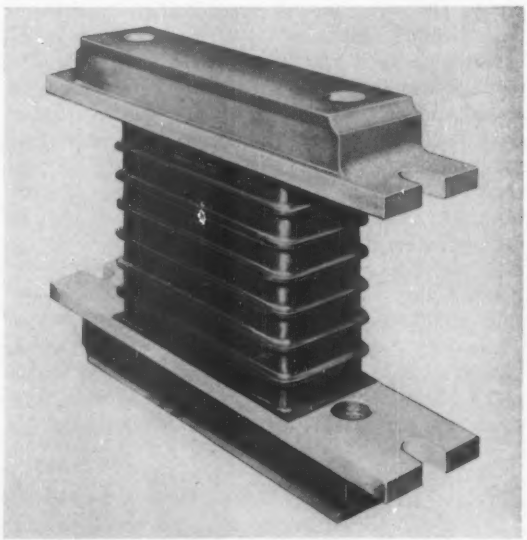


Table 1—Shear Modulus of Elastomers

Shore Durometer	Shear Modulus, Static*	Shear Modulus, Dynamic†	Modulus Ratio (Dynamic to Static)
40	54	65	1.2
42.5	62.4	78	1.25
45.5	72	93.5	1.3
49	83	112	1.35
52	96.5	135	1.4
55.5	112	162	1.45
59	130	194	1.5

*Static data taken at 150 per cent shear strain; 0.01 cps.
†Dynamic data taken at 150 per cent shear strain; 2 cps.



Traction-motor nose support incorporates metal plates to reduce bulge area, making the mount stiff in compression. Laminated-plate design adds only slight stiffening in horizontal direction.

other direction. Each condition would have to be considered separately to determine probable life.

Hardness or modulus required of the stock is often established by physical limitations—where certain motions are to be accommodated within a given space envelope. Increasing the hardness of an elastomer demands either a higher stress or a larger volume of elastomer to obtain a required elastic rate. Since work is the product of force and deformation, maintaining equal work per cycle in the same volume of a harder stock would require reducing the shear area by the ratio $(G_1/G_2)^{1/4}$ and increasing the sandwich thickness by the inverse of this ratio, where G_1 and G_2 are the shear moduli of the softer and the harder stocks respectively.

Harder stocks, both synthetic and natural, tend toward longer life in terms of total energy flow and can accept greater ranges of stress than softer stocks. The greater reinforcement from pigments such as carbon black is responsible for these characteristics of the harder stocks. However, considerations of size and shape of parts often require the use of softer elastomer materials.

For these reasons it is usually convenient to design with 40 durometer characteristics in mind. If a design is required, for example, using a 52 durometer elastomer, Table 1 shows a dynamic modulus of 135 for 52 durometer stock and 65 for the 40 durometer reference stock. These factors can be applied to arrive at a very acceptable approximation. Then, in a simple shear sandwich, the bonded area of the stiffer stock should be $(65/135)^{1/4} = 69$ per cent of the area of the softer stock, and the thickness should be $(135/65)^{1/4}$, or 1.44 times that of the reference stock.

If a requirement involves a range of frequencies, or if random impacts and excitations are to be isolated, it is sometimes necessary to design for more than 20 per cent hysteresis loss. In this range, extreme care is required in selecting the elastomer if creep is to be held to a low value. Whether excitation comes from the base or from the mechanism, rigidity and mass of the base are important, since damping in the mountings alone may not be effective without special attention to tuning.

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Simplified procedures for finding maximum deflection of

Beams with Partial Uniform Loading

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CHARTS and equations presented here were developed to simplify calculation of reactions, positions of maximum deflection, and magnitudes of maximum deflections for simply supported and built-in beams under partial uniform loading. The charts are useful either in the study of deflection or in the calculation of reactions and fiber stresses. Basic design equations are expressed in terms of nondimensional ratios representing the relations between the loaded and unloaded portions of beams. This form of expression offers certain advantages in the execution of final calculations.

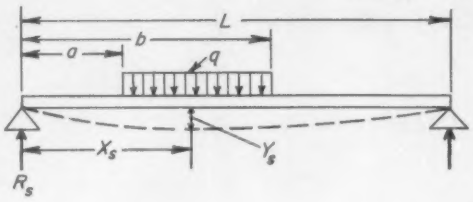
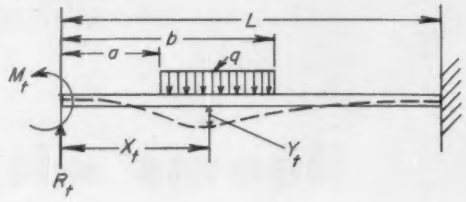
Nomenclature

a	= Distance from left support to loaded portion, in.
b	= Distance from left support to end of load, in.
E	= Modulus of elasticity, psi
I	= Moment of inertia of beam cross-section, in.^{4}
K_1, K_4	= Reaction factors for simple support and built-in support, respectively
K_2, K_6	= Factors for calculating position of maximum deflection with simple support and built-in support, respectively
K_3, K_7	= Deflection factors for simple support and built-in support, respectively
K_5	= Fixing couple factor for built-in support
L	= Total length of beam, in.
M_t	= Fixing couple, lb-in.
m	= Length ratio $= a/L$
n	= Length ratio $= b/L$
q	= Uniform load, lb/in. of span
R_s, R_t	= Left reactions for simple support and built-in support, respectively, lb
X_s, X_t	= Distances from left support to point of maximum deflection for simple support and built-in support, respectively, in.
Y_s, Y_t	= Maximum deflections for simple support and built-in support, respectively, in.

In this analysis, beams are considered to be homogeneous, uniform in section, and long in proportion to their depth and width. Hence, the effects of shear and stiffening (due to Poisson's ratio) on deflection may be safely ignored. For practical purposes, beams are considered to be long in relation to depth when the ratio of span to depth exceeds 8. When beams have thin webs, this ratio should be 15 or more. When beams are disproportionately wide, various rules and corrections have been proposed, depending on the manner of support, method of loading, and the ratio of width to span. In general, wide beams prove to be more rigid than the standard deflection formulas indicate.

The procedure followed in the derivation of the design charts was first to establish general equations for deflection at any point of a beam with partial uniform loading. Such expressions involved a great many terms. Therefore, it was necessary to carry out the calculations in various steps. The general equations for deflection were then differentiated to find the value of X at which the deflection was a maximum. Finally, substitution of these values in the

Table 1—Design Relationships for Beams with Partial Uniform Loading

Simple Support	Built-in Support
Beam form, conventions, and symbols	
	
Left Reaction	
$R_s = qLK_1$ .....(1)	$R_f = qLK_4$ .....(4)
Fixing Couple	
.....	$M_f = qL^2K_5$ .....(5)
Position of Maximum Deflection	
$X_s = LK_2$ .....(2)	$X_f = LK_6$ .....(6)
Magnitude of Maximum Deflection	
$Y_s = \frac{qL^4}{EI}K_3$ .....(3)	$Y_f = \frac{qL^4}{EI}K_7$ .....(7)

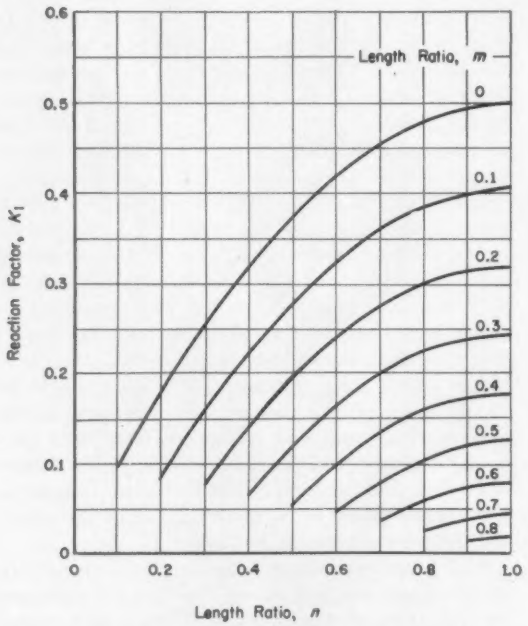


Fig. 1—Above—Values of factor K_1 for determining reaction R_s of a beam with simple supports.

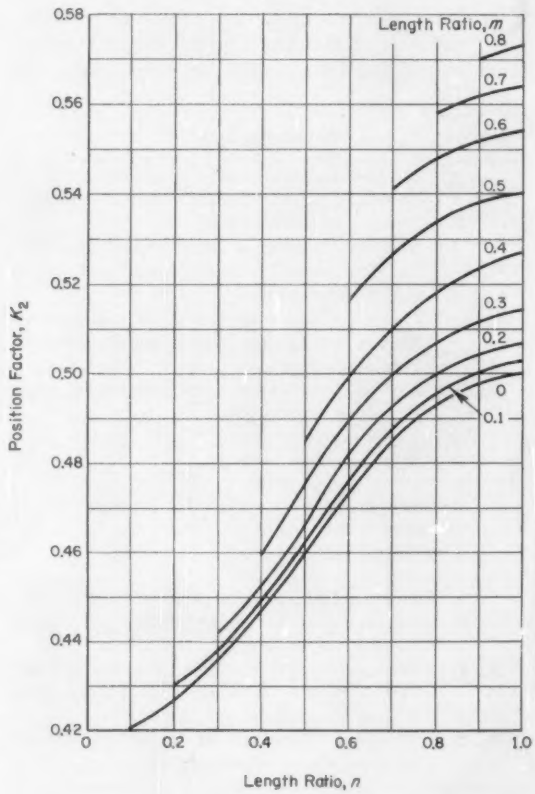


Fig. 2—Right—Values of factor K_2 for calculating position X_s of maximum deflection of beam with simple supports.

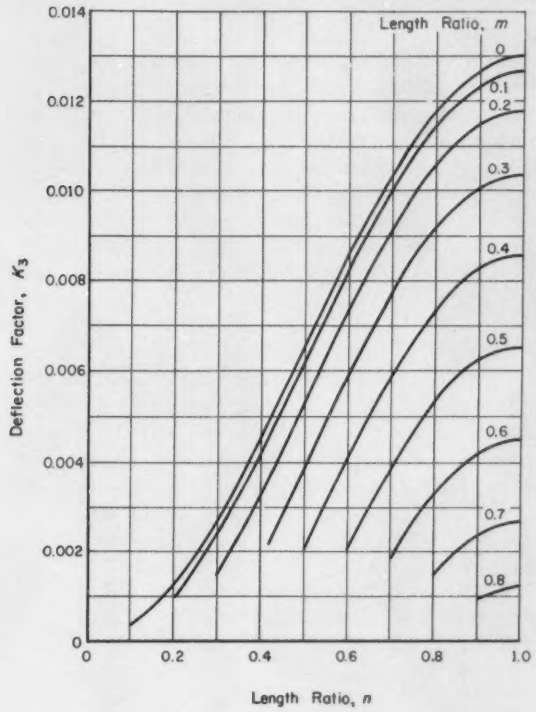


Fig. 3—Values of factor K_3 for calculating magnitude of maximum deflection Y_1 of beam with simple supports.

deflection formulas gave the required results.

Schematic diagrams, conventions, and design equations for simply supported and built-in beams with partial uniform loading are given in Table 1. Symbols are defined in Nomenclature and Table 1.

Simply Supported Beams: Derivation of deflection charts for simply supported beams under partial loading was preceded by two steps which are expressed by Equations 1 and 2, Table 1.

Left side beam reaction is computed with Equation 1. Factor K_1 for this equation is plotted as a family of curves in Fig. 1 for various values of nondimensional ratios m and n. Factor K_2 of Equation 2, which is used for finding the position of maximum deflection, is illustrated in Fig. 2. Maximum deflection is calculated with Equation 3. Factor K_3 for this equation is obtained from Fig. 3.

Built-in Beams: In the case of the beam with built-in supports, three preliminary steps were neces-

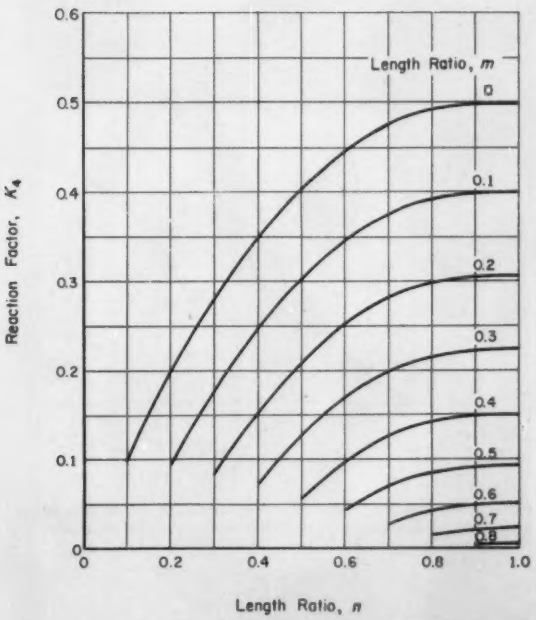


Fig. 4—Values of factor K_4 for determining reaction R_1 of a beam with built-in supports.

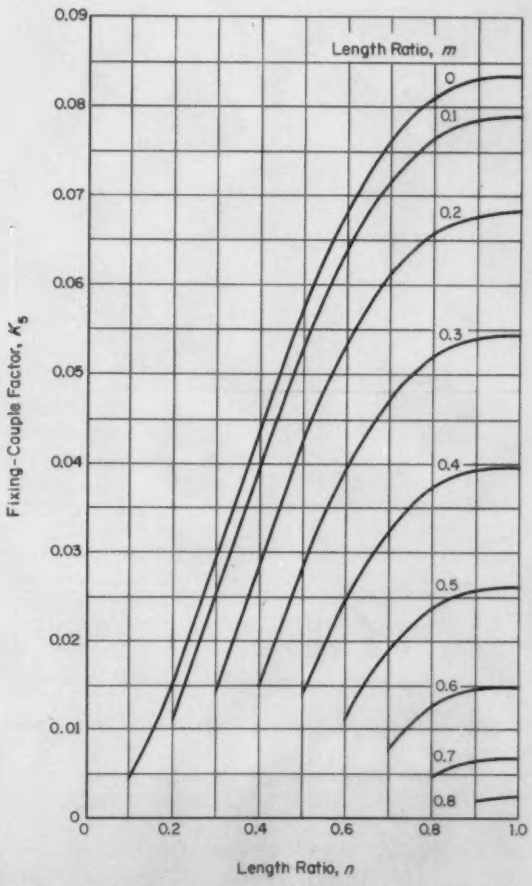


Fig. 5—Values of factor K_5 for calculating fixing couple M_1 of beam with built-in supports.

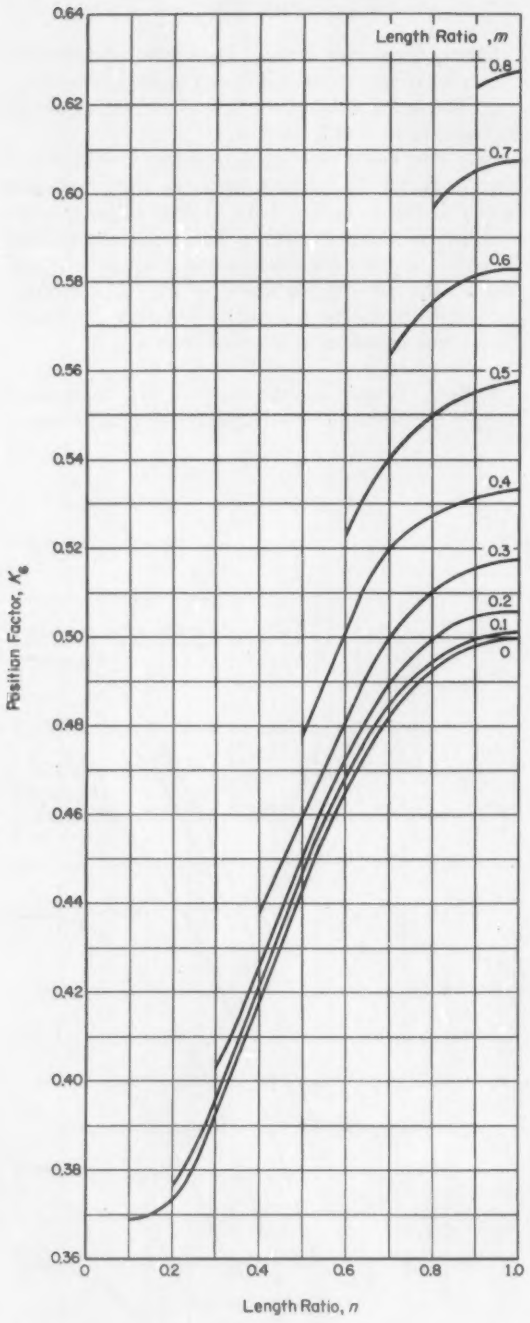


Fig. 6—Values of factor K_6 for calculating position X_s of maximum deflection of beam with built-in supports.

sary before deriving final charts for maximum deflection. Equations 4, 5, and 6 refer to the left support, as do corresponding Equations 1 and 2 for simply supported beams.

Design charts for values of factors K_4, K_5, and K_6 are provided in Fig. 4, 5, and 6, respectively. As for simply supported beams, nondimensional ratios m and n are used. Maximum deflection is calculated with Equation 7 where factor K_7 is obtained from Fig. 7.

Example: A horizontal steel I-beam of uniform cross section and 20-ft length rests on rigid end supports and carries a uniformly distributed load of 0.5 ton per ft over 6 ft of its length. Distance a from the left support is 2 ft. Assume that moment of inertia I for a standard I-beam is 795.5 in.^{4}

Calculate the position X_s and magnitude Y_s of the maximum deflection. Take modulus of elasticity $E = 30 \times 10^6$ psi.

Length parameters are $a/L = 0.1$, and $b/L = 0.4$. Position of deflection is found from Equation 2 and Fig. 2. Here, $K_2 = 0.449$ and $X_s = 0.449(20) = 8.98$ ft, measured from the left support. Corresponding maximum deflection is obtained from Equation 3 and Fig. 3. Hence, $K_3 = 0.0042$, and $Y_s = 0.0486$ in.

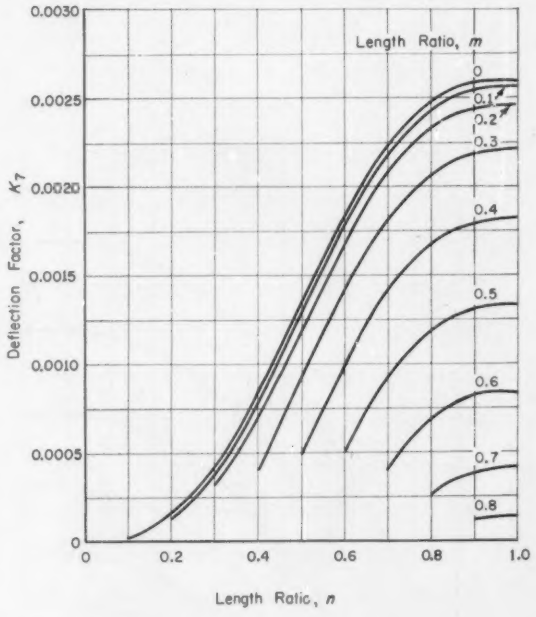
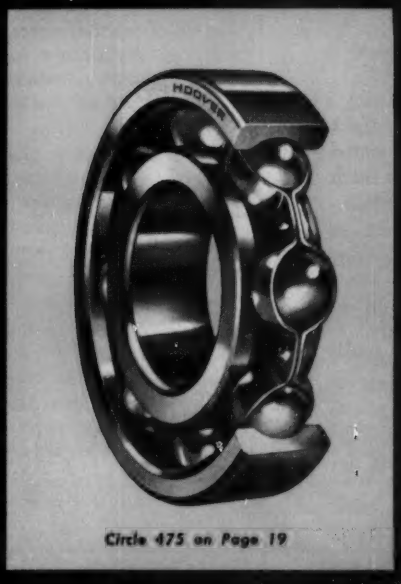


Fig. 7—Values of factor K_7 for calculating magnitude of maximum deflection Y_s of beam with built-in supports.

so quiet...



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Design techniques and concepts for

Microelectronic Circuits

B. G. BENDER, WM. B. WARREN, R. A. GUDMUNDSEN, and E. L. STEELE

Semiconductor Div., Hughes Aircraft Co., Newport Beach, Calif.

CONSIDERABLY advanced types of microelectronic circuits are currently under study. However, useful products will be slow to emerge. The system described here is expected to find widespread application for many years to come.

In this system, subminiature active components, such as diodes and transistors, presently known and of contemporary design, are assembled into small, very thin packages. Then these packages are assembled into evaporated, chemically formed circuits. The circuits contain resistors and capacitors which may be deposited on the substrate or inserted in microelectronic component form. Connections between components are completed by evaporation, soldering, or other means.

The system is primarily centered about circuit elements 0.050 in. diam by 0.030 in. thick. Diodes, resistors, and capacitors in this form have gold-clad end plates for attachment into the circuitry. Transistors have the collector contact in a similar 0.050 in. diam end plate, with emitter and base leads emerging in two plates on the opposite surface.

Components can be inserted within the body of a board which carries the associated circuitry on its two major surfaces. Devices are carried in 0.052 in. diam through-holes in a 0.030 in. thick substrate and the holes are located on a 0.100 in. square matrix. Such spacing is adequate for inter-component connection, yet is not so tight as to cause accidental short circuits.

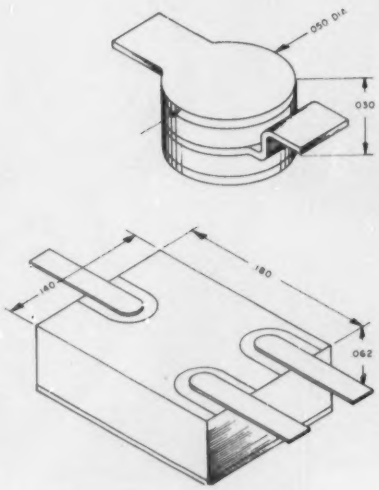

Fig. 1—Microsize transistor packages

Where the area requirement of the 0.050 in. circular component is too severe a limitation, other shapes are possible. Here the only limitations are the 0.030 in. thickness, the modular spacing choice, and the cleverness of the circuit layout designs.

Communications within groups of components are through cir-

Design Concepts

1. This system employs miniature components 0.050 in. diam by 0.030 in. thick, with other special shapes possible when absolutely necessary.
2. It is feasible to produce resistors, capacitors, diodes, and transistors in this form.
3. Ranges of device parameters, as required in most computer-type circuity, can be made available in this form.
4. A board system contains the miniature components and supports the associated circuitry.
5. The circuitry system eliminates cross-over problems and provides suitably compact wiring.
6. The board fabrication procedure is such that the circuitry is continuous. The only physical connections required are those between device and board.
7. The board fabrication procedure is based upon opti-chemicals machining of the substrate and chemical etching of the copper circuits. Only one drawing of each board surface is required.
8. The only assembly operations subsequent to receipt of boards are insertion and connection of devices.
9. Every individual component is accessible for test and replacement while numbers of boards are connected into a system and are operating.
10. A high order of system reliability is inherent.

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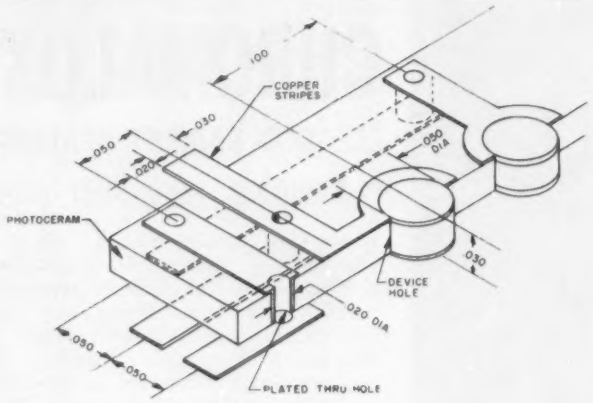
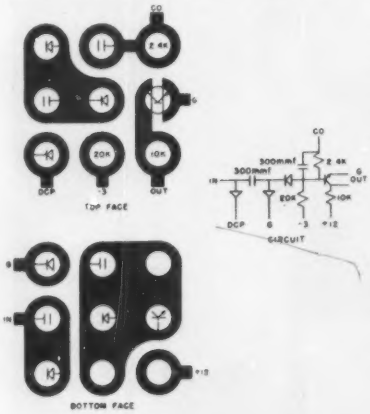


cuitry from hole to hole on the two surfaces of the board. The sole connection is that between devices and immediately adjacent inter-hole-circuitry on the 0.100 in. square modulus. Nominally, not more than ten devices are intimately involved at the group level. Connected to the group are power supplies and signals, in and out.

Each diode is hermetically sealed within a 0.050 in. diam ceramic cylinder, closed at each end by a gold-clad metal plate. The die is fused to one plate of magnetic material, while the diode lead is fused to the opposite plate of nonmagnetic material. The entire assembly is 0.030 in. high.

Additional structure is required for a transistor device to accommodate and isolate the third lead. One form of the transistor carries two isolated half-plates on one face of the cylinder, one connected to base and the other connected to emitter. Another package for the transistor is contained within a maximum envelope 0.180 by 0.140 by 0.62 in., Fig. 1.

(Above)
Fig. 2—Typical inter-group circuit syste



(Above)
Fig. 3—Representative subassembly composed of six kinds of modules.

For mounting boards, Corning Fotoceram appears best suited. This relatively high dielectric strength, inorganic material can be "machined" by a combination of photographic and chemical procedures. In addition, printed circuitry, including through-connected holes, can be laid down in 0.002 to 0.006 in. thickness on both major surfaces. For reliable connections between inserted devices and surface stripes, ultrasonic welding appears quite suitable.

The inter-group circuit system employs horizontal circuit stripes on one face of the board and vertical ones on the opposite surface. Stripes are 0.030 in. wide, separated by 0.020 in., employing a 0.050 in. modulus.

Wherever connection is to be made between a horizontal and a vertical stripe, a 0.020 in. diam hole is cut through the plate before the circuitry is laid down. Using this stripe system, no cross-over problem exists. There is a continuing the edge of the board for interconnection except where a plated through-hole is placed, Fig. 2.

Power supply busses and in-and-out leads are brought to pads at the edge of the board for itner-board connection.

For an example, this system is applied to the circuit of a full adder. The complete adder is built up from six individual kinds of blocks. Two are transistorized amplifiers, three are "and" gates, and the remaining element is a flip-flop half. These groups are laid out as shown in Fig. 3.

To accommodate groups so laid out, the complete board employs the standard 0.100 in. square modulus for device holes and the 0.050 in. modulus for inter-group connections, Fig. 4.

Note that inter-group circuitry absorbs a great deal of space relative to that required for devices alone. By judicious employment of the possibilities inherent in over-under circuitry, the entire adder is

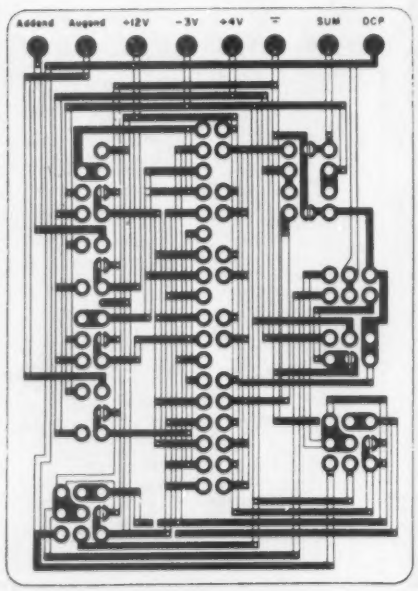


Fig. 4—Complete adder contained on a single substrate, 0.040 in. thick, 2 in. wide, and 2¾ in. high.

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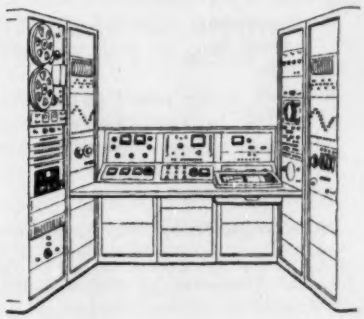

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WESCON paper, "The Hughes Type 1 Microelectronic Circuit Concept," presented in Part 3, Session 30, IRE Western Electronic Show and Convention, Los Angeles, 1960, 6 pp.

bearings

Gas-Lubricated Thrust-Bearing

A. Nahavandi, Westinghouse Electric Corp., and F. Osterle, Carnegie Institute of Technology.

A nonpressurized, parallel-surface, gas-lubricated thrust bearing with the slider in steady spin and precession. Operation of this self-acting thrust bearing over a range of conditions is studied and the results applied to the so-called bevel bearing. The load capacity is obtained numerically by solving the Reynolds equation for compressible lubricant in finite difference form. The bearing is found to develop significant load capacity.

ASLE Paper 60 LC-13, "A Novel Form of Self-Acting Gas Lubricated Thrust Bearing," presented at the ASLE/ASME Lubrication Conference, Boston, Oct., 1960, 7 pp.

electrical

DC to AC Power Conversion By Semiconductor Inverters

E. J. Duckett, New Products Laboratories, Westinghouse Electric Corp., Cheswick, Pa.

Evaluation of methods for converting large amounts of power from dc to ac. Several reliable and efficient inverters are available, and among them is a promising newcomer—the newly developed semiconductor power inverter.

Fundamentally, inverters are of three types: The conventional motor-generator set, the mercury-arc rectifier (ignitron) inverter, and the new semiconductor power inverter. Both ignition and semiconductor inverters are basically static units as opposed to the rotating motor-generator set. These three methods are compared in terms of their present and potential capabilities.

"DC to AC Power Conversion—by Semiconductor Inverters," Westinghouse Engineer, Vol. 20, No. 6, Nov., 1960, pp. 170 to 174.

management

Improving Technical Conference Presentations

Irvin J. Fong, Remington Rand Univac Div. of Sperry Rand Corp.

Countermeasures to meet the dilemma of an ever-increasing output of documents and a corresponding failure to communicate them. Technical competence alone is not enough in a conference presentation. A direct approach is proposed in which management plays a major role. It describes how one company, Remington Rand Univac of St. Paul, initiated a series of in-plant training sessions, dry-runs of papers, workshops, and speaking-writing classes to help prepare potential authors in paper presentations.

WESCON Paper, "The Rightful Role of Management in Technical Communications," presented in Part 8, Session 6, IRE Western Electronic Show and Convention, Aug., 1960, 4 pp.

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William A. Smith Jr., director, Computing Laboratory, Lehigh University.

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presented at the Eighth Annual Engineering Management Conference, Chicago, Sept., 1960, 4 pp.

materials

Metals as Transmission Fluids At High Ambient Temperatures

R. C. Kumpitsch and J. R. Granan, Light Military Electronics Dept., General Electric Co., Schenectady, N. Y.

Results of search for a liquid metal to function as a hydraulic fluid at 1000 F ambient. The metal showing the best possibilities was the eutectic alloy of sodium and potassium, NaK-77:

1. It behaves in an entirely predictable manner.
2. It is adaptable as a hydraulic fluid from 0 to 1400 F since it remains a liquid over this range.
3. It shows no signs of deterioration with temperature or time in a closed system.
4. The problems which exist in the application of this fluid for high-temperature service appear to be far less formidable than those presently confronting other fluids for this type of service.
5. Many of the more common materials are compatible with NaK at 1000 F and will give long and satisfactory service.
6. NaK-77 is the only fluid presently available for applications where an extremely wide operating temperature range—10 to 1400 F—and long operational life are important.

NCIH paper, "Liquid Metals, Applications as Power Transmission Fluids," presented at the 16th annual meeting of the National Conference on Industrial Hydraulics, Chicago, Oct., 1960, 24 pp.

Friction and Wear of Metals In Gas Environments

D. F. Cornelius and W. H. Roberts, United Kingdom Atomic Energy Authority.

Comparison of copper, mild steel, and brass, rubbed against a hardened tool steel at room temperature in four environments: Vacuum (10^{-3} mm Hg), dry helium, dry carbon dioxide, and dry air. The effect of varying the water vapor content in air is also discussed.

Initial selection of rubbing pairs for service at elevated temperatures in gaseous environments under un-

lubricated conditions is based on their long-term resistance to corrosion and their ability to give low wear rates. In general, therefore, the materials must be hard. Several alloys having chromium contents of between 1 and 30 per cent, and hardness values in the range 200-100 vpn (Vickers Pyramid Number) have been investigated. These include two low-chromium nitrided steels, a tungsten-chromium tool steel, and a series of four Co-Cr-W alloys. Specific wear rates, k, and friction coefficients, μ, vary markedly with temperature, and values in the ranges, $K = 10^{-3}$ to 10^{-8} and $\mu = 0.1$ to 0.8, are obtained in both dry carbon dioxide and dry helium. Lowest wear rates are observed with the nitrided steels. The diverse characteristics observed are discussed on the basis of current theories of adhesive wear.

ASLE Paper No. 60-LC-9, "Friction and Wear of Metals in Gases up to 600 C," presented at the ASLE-ASME Lubrication Conference, Boston, Oct., 1960, 13 pp.

mechanical

Two-Stage Planetary Train For 15 to 1 Reduction

Edward A. Brass, senior design engineer, Lycoming Div., AVCO Corp.

A lightweight, compact, high-efficiency transmission with a speed reduction ratio of 15:1. The "split-power" two-stage planetary arrangement offers the best solution to design requirements for light weight and minimum overall dimensions.

In split power transmission, it is often advisable to locate the primary stage forward of the secondary stage. This results from the difficulty in assembling the second stage assembly over the output thrust-bearing shoulder. Power from the secondary stage can be delivered to the propeller shaft by means of a torque tube attaching to the forward half of the primary carrier. Among other advantages, this construction avoids transferring the secondary-stage output power along the prop-shaft extension and across the primary-carrier parting surface.

ASME Paper 60-SA-1, "Two Stage Planetary Arrangements for the 15:1 Turboprop Reduction Gear," presented at

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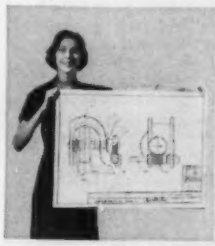

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Circle 480 on Page 19

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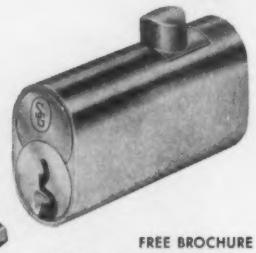

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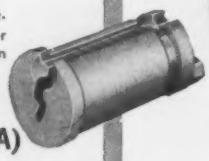

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Circle 481 on Page 19

New Line of corrosion-resistant needle valves

MARSH
Needle Valves
in 316 STAINLESS STEEL

Throttle flow and throttle corrosion with this new valve series that gives you the superlative construction of Marsh Needle Valves with the corrosion-resistance of 316 stainless steel.

Here is a valve that gives you precision throttling and tight closure on pressures from a few pounds to 6000 psi. Wide temperature range, too—from minus 100°F. to plus 500°F. —as a result of the Marsh "Marpak" packing system utilizing precision moulded Teflon.

New 316 stainless series (series 1936) is identified by blue handle. Sizes from ⅛" to 1"; globe, angle, and panel mounted patterns.

Marsh Needle Valves are also available in 416 stainless steel (identified by green handles) and in alloy steel (identified by yellow handles).

Ask for bulletin NV-3

MARSH INSTRUMENT COMPANY, Dept. B, Skokie, Ill.
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas

Circle 482 on Page 19

the Summer Annual Meeting, Dallas, Tex., June, 1960, 8 pp.

Gas Turbine Applications

D. F. Bruce, section manager, Industrial Gas Turbine Engineering, Westinghouse Electric Corp., Philadelphia.

Characteristics of the gas turbine which make it useful as a power source in industry. Paramount among these advantages are its ability to use many different fuels (including the waste gases of some processes), its delivery of large amounts of thermal energy in the exhaust gas at usable temperature and pressure, and its ability to operate in a range of speeds and shaft powers. In addition, the exhaust gas contains about 80 per cent of the oxygen of the intake air, so it can be used as preheated combustion air for a boiler, as the energy supply for a process heat exchanger, and in other ways.

"Gas Turbine Applications in Industry," Westinghouse Engineer, Vol. 20, No. 6, Nov., 1960, pp. 188 to 192.

hydraulic

Advances in Lip Seal Technology

Robert L. Dega, engineering supervisor, Research Laboratories, General Motors Corp.

Information in regard to the variables which affect seal applications. These are enumerated in the order of their importance: Shaft, assembly, lip dimension variables, and lip material quality. One of the most important contributions as a result of this research is the fact that shaft finish and assembly conditions are as great a factor in seal leakage as the sealing element itself.

NCIH paper, "Recent Advances in Lip Seal Technology," presented at the 16th Annual National Conference on Industrial Hydraulics, Chicago, Oct., 1960, 11 p.

High-Performance Pneumatic Controllers

Frank J. Finegan Jr., Aeronautical Equipment Div., Sperry Gyroscope Co.

A method of analysis and design for high-performance pneumatic controllers. References throughout are made to flight control systems,

since it was for this requirement that the investigation was conducted. The final form of the transfer function and design equations is such as to be generally applicable.

ISA Paper No. ISA-13, "High Performance Pneumatic Controllers," presented at the Joint Automatic Control Conference, Mass. Institute of Technology, Sept., 1960, 24 pp.

processes

Case Thickness of Carburized and Hardened Gears

R. Pedersen, research engineer, and S. L. Rice, research metallurgist, Caterpillar Tractor Co.

An approach to the selection of case thickness of carburized and hardened gears. This paper shows the need, and provides a method, for a reasonable selection of case depth. This method is not only useful as a deseign tool but is an aid in determining the cause of failure on gear tooth profiles. Equally important is the separation of a distinct type of failure—case crushing—from other gear tooth profile failures.

SAE Paper No. 220B, "Case Crushing of Carburized and Hardened Gears," presented at the SAE National Farm, Construction and Industrial Machinery Meeting, Milwaukee, Sept., 1960, 7 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:
ASLE—American Society of Lubrication Engineers, 5 North Wabash Ave., Chicago 2, Ill.; papers 50 cents to members, 75 cents to nonmembers.
ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.
EMC—8th Annual Engineering Management Conference, collected papers available from American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., $5.00 per set.
ISA—Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.
NCIH—16th Annual National Conference on Industrial Hydraulics, Conference Proceedings available from W. R. Smith, Conference Secretary, 3300 South Federal St., Chicago 16, Ill., $6.00 per copy.
SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.
WESCON—Western Electronic Show and Convention. Convention Record, Part 3, $1.50 to IRE members, $5.00 to nonmembers, Part 8, $1.05 to IRE members, $3.50 to nonmembers, available from Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y.
Westinghouse Engineer, P. O. Box 2278, 3 Gateway Center, Pittsburgh 30, Pa., 50 cents per single issue.

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You can drive up to 40 screws per minute with a DPS Model U. Nuts are driven equally fast . . . with accuracy that cuts parts waste, improves assembly quality.

DPS offers the Model U in two types: pedestal, and self-contained driving head. Both require minimum space and are readily adaptable to your work flow. Feed track and escapement mechanism mounts on either side of the machine column for right- or left-hand assembly. The versatile self-contained driving head is ideal for use in automatic assembly machines incorporating dials and straight-line transfers.

The Model U drives screws from #6 x 3/16" long to 1/4" x 1 1/2" long . . . and can be equipped with 12" or 16" barrel feeders.

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Circle 483 on Page 19

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Compact Motors

Bulletin 2650 features a complete range of compact motors, 1/3 through 40 hp, in either high-inertia axial air-gap or low-inertia radial air-gap design. Ratings are available in open, nonventilated, and totally enclosed, fan-cooled construction for integrated machine-tool applications. Various types of units are pictured, and salient features are pointed up. 4 pages. Electrical Div., Fairbanks, Morse & Co., Freeport, Ill.

Circle 601 on Page 19

Card Reader Switch

New brochure, Form SP 260, describes Cardmatic card reader switch. Literature contains complete specifications on the unit, which employs a rubberized vinyl card as its programming medium. Examples of ways in which the card reader has been utilized in card-programming equipment are provided. Master card punch, used to punch programming cards in one operation, is also described. 6 pages. Hickok Electrical Instrument Co., 10612 Dupont Ave., Cleveland 8, Ohio.

Circle 602 on Page 19

Copying Machine

New brochure illustrates and describes the Xerox Copyflo 1824 printer, which uses ordinary paper. It turns out a dry positive engineering print up to 18 x 24 in. in size, from a microfilm frame mounted in a data-processing card. Features of the unit are pointed out, and photographs describe the simple, rapid operation. 4 pages. Haloid Xerox Inc., Dept. 1824, Rochester 3, N. Y.

Circle 603 on Page 19

Spring Fasteners

Standard and special spring fasteners in twin-prong or cone-type impressions and push-on types are illustrated in new catalog. Data are arranged so that selection of fastener by style, screw, or stud size is made easily. Information concerning tensile strength, torque, and other pertinent design requirements is provided. 14 pages. George K. Garrett Co. Inc., Dept 216, Torresdale Avenue at Tolbut Street, Philadelphia 36, Pa.

Circle 604 on Page 19

High-Temperature Alloys

Quick reference to the comparative properties of a line of high-temperature alloys is contained in new booklet. Seventeen leading alloys are compared in the areas of physical, mechanical, and chemical properties, and stress-rupture data. Easily interpreted charts show selected properties for each alloy at specific temperatures. Data cover the alloys in various forms, such as sheet, bar, sand, and investment castings. 20 pages. Dept. CP, Haynes Stellite Co., Div., Union Carbide Corp., 270 Park Ave., New York 17, N. Y.

Circle 605 on Page 19

Temperature Controls

Transistor circuits and thermistor sensing elements are among the features of four new temperature controllers described in Bulletin MC-190. Detailed specifications are given for the four units. Bulletin points out wide choice of optional features, and sketches are included of various application arrangements. 8 pages. Fenwal Inc., Pleasant St., Ashland, Mass.

Circle 606 on Page 19

Color-Coded Pushbuttons

Colorful Bulletin PL 100-1-960 provides design information on three separate but related lines of pushbutton stations and control units for heavy duty. Described are pushbutton units, selector-switch units, standard pilot lights, and push-to-test pilot lights or lighted pushbuttons. Sequence description is given of wipe-action contacts. Color-selection chart shows available combinations of seven colors for color coding both buttons and ferrules in the control units. 8 pages. Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio.

Circle 607 on Page 19

Static Metal Seals

Technical memoranda 1001, 1002, and 1003 cover all aspects of problems relating to the care, handling, installation, and storage of static metal seals. Included in the scope of the articles are data pertaining to proper lubrication, cleaning, and specific torque requirements of the various types of seals listed. 10 pages. Harrison Mfg. Co., 2908 Naomi St., Burbank, Calif.

Circle 608 on Page 19

Rotating Transmission

Control flexibility, high torque capacity, and compact size are significant features of a new rotating transmission described in Bulletin IR-60. Bulletin describes and illustrates the Roto-mission, and provides charts, tables, diagrams, and cutaway drawings. Details of construction, tables of available ratios and ratings, dimensions, illustrations of design and construction, and details on progressive overload capacity are furnished. Typical applications are listed. 8 pages. Industrial Div., Airborne Accessories Corp., 1414 Chestnut Ave., Hillside 5, N. J.

Circle 609 on Page 19

Wire-Wound Resistors

Catalog 14RE covers the entire line of encapsulated and bobbin-type, wire-wound resistors featuring standard tolerance of ± 1 per cent and special tolerances as low as 1/20 per cent. Complete technical details and performance characteristics are provided, along with illustrations and large size and rating charts. 20 pages. Cinema Engineering Div., Aerovox Corp., 1100 Chestnut St., Burbank, Calif.

Circle 610 on Page 19

Testing Instruments

Summary brochure contains basic specifications on pressure transducers, position instruments, accelerometers, and instrument systems. Thirteen new instruments are introduced in the brochure. General information on each line is included, giving typical applications, features, and operating principles. Specifications such as range, resistance, resolution, error bands, linearity, hysteresis, size, and weight are also included for each instrument. 20 pages. Instrument Div., Bourns Inc., 6135 Magnolia Ave., Riverside, Calif.

Circle 611 on Page 19

Belting

Form 1003-E250 gives complete specifications and information on a full line of conveyor, elevator, and transmission belting. In addition to the detailed data, cross-section illustrations show the construction of each belt. Section is devoted to helpful tables dealing with belt weights, gages, fabrics, and recommendations. 36 pages. Boston Woven Hose & Rubber Div., American Biltrite Rubber Co., Box 1071, Boston 3, Mass.

Circle 612 on Page 19

Manual Motor Starters

Bulletin GEA-6358C describes CR101 manual motor starter for fractional-horsepower motors, and CR1062 starter for integral-horsepower motors to 7½ hp. Publication includes photographs with callouts giving construction features of both units, and outline diagrams show dimensions. Heater selection tables and prices for both types are also included. Photographs depict two basic forms available for each type starter. 12 pages. General Electric Co., Schenectady 5, N. Y.

Circle 613 on Page 19

F *is for FINISHES*

This anodic finishing unit is one of our many units capable of a variety of mechanical, chemical finishes. All part of our mill-to-final-finish facilities, at your service.

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Receiver Gages

Complete line of dial-indicating receiver gages is described in Catalog 520. Receiver gages are special-purpose, low-pressure units used to indicate values transmitted by pneumatic signal from a remote location, usually in the range of 3-15 psi. Catalog gives specifications for both bourdon tube and diaphragm-actuated types. It also contains information on materials, dials, ranges, case styles, and sizes. 8 pages. United States Gauge Div., American Machine & Metals Inc., Sellersville, Pa.

Circle 614 on Page 19

Carbon Film Resistors

New brochure describes Gold Seal carbon film resistors. Drawings are given for the various types, with tables providing information on ratings, resistance ranges, sizes, and capacities. Characteristics are pointed out, and curves are provided for temperature coefficient, derating curve, and pulse test. Standardization chart is also included. 4 pages. Technology Instrument Corp., 531 Main St., Acton, Mass.

Circle 615 on Page 19

Cable Ties and Straps

Nylon cable ties and straps for securing and identifying wiring bundles are described in Bulletin TR3. Bulletin shows applications using Ty-Rap cable ties and straps, lists complete line, and gives installation instructions. Military specifications which the ties and straps meet are also included. 4 pages. Thomas & Betts Co., 36 Butler St., Elizabeth, N. J.

Circle 616 on Page 19

Universal Joints

Illustrated Catalog J-1960-1 covers universal joints for agricultural and implement fields. Included are universal-joint engineering data, complete joint specifications, servicing instructions, and ordering information. Engineering drawings and tables are provided. 66 pages. Mechanics Universal Joint Div., Borg-Warner Corp., 2020 Harrison Ave., Rockford, Ill.

Circle 617 on Page 19

Indicator Lights

Form L-160B discusses ultraminiature indicator lights, Datalites, and their use either singly or in multiples. Two basic types are described. Also described are Data Cap Series 250, as well as cartridge connectors and speed clips. Brochure gives complete lamp data, features, specifications, illustrations, and schematics. 8 pages. Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.

Circle 618 on Page 19

Cam Followers

Bulletin lists 13 both CFH and SCFH (sealed) series of heavy-stud Camerol cam followers. Drawings, special features, and mounting instructions are given for both series. Dimensional data for all models of both series, tables for determining speed factors, life factors, proper stud size, minimum boss support, and recommended clamping torques have been included in the bulletin. 4 pages. Bearing Div., McGill Mfg. Co. Inc., Valparaiso, Ind.

Circle 619 on Page 19

Spiral Spacer

Universal-type spiral spacer for use when joining crushable panels to other parts or panels is described in Form 8-659. Brochure outlines many potential uses for the spacer, and illustrates a variety of typical applications with cross-section line drawings. Required hand tools are illustrated; their use in installation of the spacer is illustrated with step-by-step procedural drawings. Tabulation of suggested hole-preparation data is also included. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.

Circle 620 on Page 19

Power Springs

Line of flat spiral power springs, including two variations of new spring design, is covered in new booklet. Four spring types are illustrated and described. Information is given on applications of the various types, as well as on specific examples of spring problems which have been solved. Booklet provides reference data on spring nomenclature, various types of ends and centers, and lists data required when ordering. 12 pages. Spring Dept., Sandvik Steel Inc., 1702 Nevins Rd., Fair Lawn, N. J.

Circle 621 on Page 19

All-Metal Seal

Bulletin BX-1 summarizes the engineering features of new, all-metal Bar -X-seal for −450 to +1200 F temperature use. Contained in the two-color brochure are diagrams illustrating the engineering concept and typical static and dynamic sealing applications. Engineering features and ordering information are also included. 4 pages. E. B. Wiggins Oil Tool Co. Inc., 3424 E. Olympic Blvd., Los Angeles 23, Calif.

Circle 622 on Page 19

Variable-Speed Belting

Bulletin VS-60 provides information on new variable-speed belt. Instructions for use of the belt are given, as well as photographs of examples. Belting is available by the foot, and table of sizes is given. 4 pages. Brammer Corp., 486 Broadway, New York 13, N. Y.

Circle 623 on Page 19

Precision Switches

Catalog 10-1 contains detailed information on snap-acting precision switches. Comprehensive data on five new series are included, as well as on a variety of integral and auxiliary actuator styles. Pictorial index shows location of dimension drawings, descriptions, force and movement specifications, electrical ratings, and photographs of each switch. Data on bases, terminals, circuit arrangements, and NEMA standard definitions of switch terms are also included. 32 pages. Unimax Switch Div., W. L. Maxson Corp., Ives Road, Wallingford, Conn.

Circle 624 on Page 19

Fasteners

Complete line of bolts and nuts, cap and machine screws, washers, cotter pins, nails and tacks, escutcheon pins, and rivets is listed in Catalog CK-17. Drawings and tables are used to provide all information on sizes, uses, and materials available. Information is provided on new Silnic bronze alloy. 28 pages. Chase Brass & Copper Co., Waterbury 20, Conn.

Circle 625 on Page 19

Flexible Couplings

Two new types of Para-flex flexible-cushion couplings, one for high-speed, high-torque applications and the other for attachment to flywheels of internal-combustion engines, are described in Bulletin 901. Complete engineering data, photographs, dimension drawings, and selection tables cover the new couplings, as well as original standard Paraflex. 20 pages. Dodge Mfg. Corp., Mishawaka, Ind.

Circle 626 on Page 19

Horizontal Conveyors

Five types of horizontal power conveyors are described and illustrated in Bulletin 19-1200. Product and installation photographs are provided for the models described. Specifications are included for the conveyors, covering standard lengths, widths, speeds, and horsepower requirements. Specifications for turntable conveyors cover diameters, speeds, and horsepower requirements. 8 pages. Rapids-Standard Co. Inc., 342 Rapistan Bldg., Grand Rapids 2, Mich.

Circle 627 on Page 19

Drafting and Drawing Instruments

Catalog-G offers information on a complete line of drawing and measuring instruments and equipment. Included are advanced drawing sets, drawing instruments, designing aids, drawing equipment, drafting materials, computing and measuring devices, and magnifiers. Each item is clearly illustrated and described. Price list is included. 124 pages. Write on company letterhead to Alvin & Co. Inc., Windsor, Conn.

Flexible Hose

Catalog ID-100D describes all-metal flexible hose used to convey gases, solids, and fluids; for vibration control; and to compensate for motion or misalignment under high temperature, pressure, vacuum, or abrasive conditions. Detailed descriptions, specifications, and applications, together with coupling recommendations, are given for U-200 and U-250 series. Also are general-purpose industrial hose; galvanized steel, all-metal flexible exhaust and blower tubing; galvanized steel and corrugated diesel-engine exhaust tubing. 20 pages. Write on company letterhead to Universal Metal Hose Co., 2133 S. Kedzie Ave., Chicago 23, Ill.

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Each one styled, sized, and priced to give you maximum efficiency for every office or plant need.

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Circle 485 on Page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Hollow-Shaft Differentials

feature integral
V-block clamp design

For positive locking and minimum space envelope, new differentials have an integral V-block clamp located directly over the center of the assembly. Two screws tighten clamp to provide positive locking without marring the shaft. Hollow

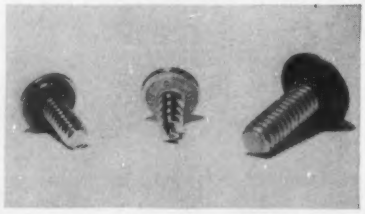
shaft permits changing axial position or length of shaft without requiring replacement of the differential. Standard backlash is 5 min maximum. All parts of the unit are stainless steel. Double ball-bearing suspension arrangement for all bevel gears is used, resulting in minimum starting and running torque. Sizes are available for 0.0550 to 0.1875 in. shaft diam. **Empire Flight Components Div., Instrument Systems Corp.**, Merrick Road, Bellmore, L. I., N. Y.

Circle 628 on Page 19

Padded Fasteners

for light to medium
torque requirements

New Barpad padded fasteners consist of finished round, hex, or flat-headed-type fastener, incorporating as an integral part, attached under the head, a compressible-type washer for insulating, sealing, and cush-



ioning. Tightening of fastener compresses washer material onto fastened member and into clearance hole between fastener and fastened member, thereby effecting insulation, sealing, or cushioning, depending on washer material used. Fasteners are designed for light to medium torque requirements and can be supplied in any size and head style of any metal and finish. When used as an insulator, they incorporate electrical grade fibrous and plastic insulation materials. As a sealing washer, they seal air, liquids, or gases in a temperature range of −65 to +1100 F. As a cushioning washer, they prevent cracking or chipping of porcelain or enameled surfaces. **L. J. Barwood Mfg. Co. Inc.**, Everett 49, Mass.

Circle 629 on Page 19

Tiny Hysteresis Motor

⅜-in. diam unit
uses less than ½ w power

New 115-v, 400-cps, single-phase, hysteresis motor measures ⅜ in. in diam by 9/32 in. in length. Unit consumes less than ½ w of power. Torque is rated at 1.5×10^{-6} hp

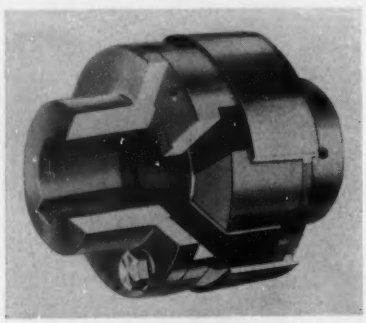
(0.0005 oz-in.), and weight of the unit is 1/9 oz. Applications include use in instruments and computers, actuating selector switches, tape handling, process timing, and others where limited space is available. **A. W. Haydon Co.**, 232 N. Elm St., Waterbury 4, Conn.

Circle 630 on Page 19

Flexible Couplings

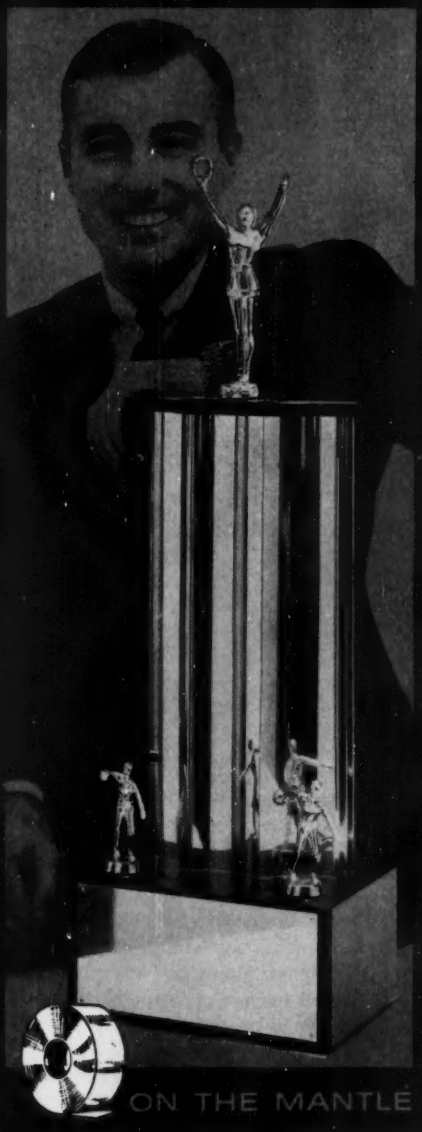
permit radial removal
of connected machinery

Standard-duty Type CQ and heavy-duty Type HQ flexible couplings incorporate one set of jaws in removable ring form, permitting both independent rotation or removal of connected machinery. Couplings employ individual, free-floating load cushions of material suited to the application. Since full load is transmitted through cushion compression only, there is no wear on the metal jaws and lubrication is never re-



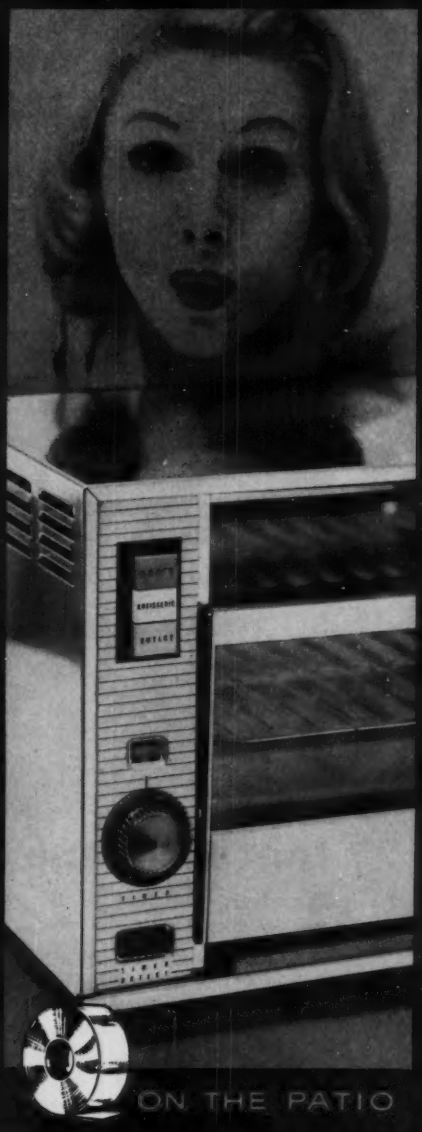
quired. Pulling a removable jaw ring outward provides enough clearance for independent rotation of either end of the coupling. By reversing a set of cap screws from one body to the other, connected machinery can be removed radially without disturbing power transmitting elements of the coupling. Type CQ couplings are available with maximum bores from 1⅜ to 5½ in. They range from 2.58 to 156 hp

NICKELOID IS EVERYWHERE



ON THE MANTLE

ON CARPETING



ON THE PATIO

These eye-catching products use functionally a basic Nickeloid Metal. The finish of Chromium, Nickel, Brass or Copper is electroplated to a base metal, usually Steel (but often Zinc, Brass or Copper).

Mostly, Nickeloid Metals are supplied in continuous coils in widths up to 24" for modern, low cost fabrication. They're also available in sheets and strips. Optional: bright or satin finishes, plating one or both sides, a galaxy of stunning patterns and crimps.

Quality plating produces metals so durable they can be fabricated, even quite severely drawn or bent. Rejects minimized. For severe stamping, we offer Mar-Not protective coating that is easily peeled off after its job is done.

Which is your preference in modern metals — the clean, flint-hard gleam of Chromium, the warmth of Copper, or the rich radiance of polished Brass? No need to answer now, but consider the galaxy of wonderful products you find everywhere today that employ one of the Nickeloid Metals. These durable, lustrous finishes are not mere lily-gilding. In most instances they are designed INTO the product . . . functionally. We make a raw material that has been given these quality finishes the *automated* way . . . in giant coils in block-long mills. Nickeloid finishes are electroplated to the base metal *before fabrication*, a process as fundamental we believe as the coating of printing papers in rolls *before they are printed*. Three out of five costly manufacturing steps are by-passed. Write for our free Introductory Kit, which includes metal samples — learn the complete story.

AMERICAN NICKELOID COMPANY · PERU 8, ILLINOIS

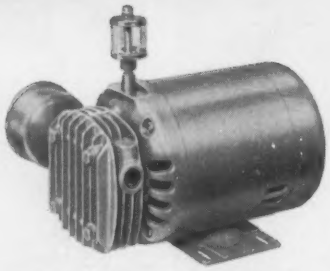
America's Pioneer Manufacturer of Pre-Finished Metals — Since 1898

Circle 486 on Page 19

new

SPACEMAKING *Perfection* VACUUM PUMP

Solves design problems wherever you need vacuum



Fewer Parts — Easier Service

It's what's inside that counts! And inside the new Perfection Vacuum pump you'll find a space-saving rotor with exclusive rotor slots that permit longer vanes, longer wear. Vanes slide freely, hug pump housing periphery, providing closer seal, higher efficiency. This simplified design permits easy removal of vanes for cleaning or replacement without disturbing pump piping or motor mounting. Many other exclusive features.

Tell us your vacuum pumping needs. Perfection can simplify original equipment design, cut costs, too.

WIDE RANGE OF SIZES	MOTOR HP	FREE AIR
	¼	2.50 c.f.m.
	⅓	5.0 c.f.m.
	½	9.0 c.f.m.

Larger, belt-driven models also available, delivering up to 36 c.f.m. at 0" Hg.

HUNDREDS OF USES

- Bubble pack and skin pack packaging.
- Poultry and food packaging machines.
- Vacuum chucks on lathes.
- Vacuum drawing of plastic sheets.
- Vacuum impregnation of ferrous castings.
- Vacuum can and bottle filling.
- Filling culture tubes and ampules.
- Small parts handling in transistor manufacture.
- Vacuum backs on cameras.
- Feeding printing presses and folding machines.
- Pad applicators.
- Many other uses.

Whatever your requirements, Perfection has a model designed and ready, right now! WRITE OR CALL OEM DEPT. 1110.

PERFECTION MFG. CORP.

A SUBSIDIARY OF STA-RITE PRODUCTS, INC.

238 S. EIGHTH STREET, DELAVAN, WISCONSIN

Sales Offices and Warehouses: Chamblee, Georgia • Los Angeles, Calif. Dallas, Texas • Woodbury, New Jersey • Denver, Colorado

In Canada: Sta-Rite Pumps (Canada) Ltd., Ajax, Ontario

Circle 487 on Page 19

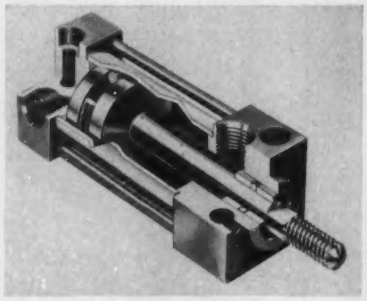
at 100 rpm. Type HQ maximum bores range from 1¾ to 8½ in., horsepowers from 7.77 to 810 at 100 rpm. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake St., Chicago 44, Ill.

Circle 631 on Page 19

Air Cylinder

midget unit is for small-force applications

Maximum 200-psi air cylinder is small enough to be held in the palm of the hand. Available in ¾, 1 and 1⅛ in. bore sizes with standard strokes to 12 in. in double-acting models, square-head Series S Midget-Air is suitable for small-force cylinder applications requiring compact



size and mounting versatility. Spring-return models are also furnished. Four basic mountings are offered, with optional clevis and flange attachments available upon request. One-piece piston and stainless-steel piston rod are permanently brazed together to prevent loosening during operation. O-ring seals assure dependable service at all working pressures. **Hannifin Div., Parker-Hannifin Corp.**, 501 S. Wolf Rd., Des Plaines, Ill.

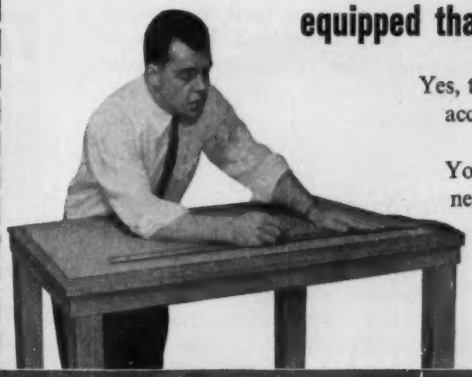
Circle 632 on Page 19

Panel Lights

can be rebulbed from front

New, low-cost panel lights feature snap-on lenses which permit rebulbing from front of panel. Lenses can be rotated to align their markings. Installation of an assembly can be made either in the panel or behind it. Lights can be used without lenses if desired. Lenses are 0.510 in. long x 0.570 in. diam; lens base is 0.600 in. diam x 0.125 in. thick. Colors are white, red, blue, amber, and green, supplied both translucent and

(What's wrong with this picture?)



Are your bookkeepers better equipped than your engineer-draftsmen?

Yes, today's bookkeeping procedures demand accuracy and productivity—equipment that guards against error, while saving time. Your professional engineer-draftsmen, too, need modern equipment for top efficiency, as their work helps establish your productivity throughout the *entire* product-planning and manufacturing cycle.

Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment—from Dietzgen

You *keep* your best men productive by giving them the equipment they need to do their best work, and you eliminate costly errors fostered by inadequate or antiquated equipment. In Hamilton equipment, *you get top productivity for every square foot of floor space.*

Not only do all Hamilton units start to pay you the minute they go on the job, but they *keep* working harder for you *every* minute—because they're so ruggedly constructed, designed for greater ease and comfort—consequently lower fatigue.

The Hamilton units are themselves a product of meticulous engineering and long experience—features and dimensions established as *ideal*, in many thousands of industrial installations. Yet they deliver the flexibility that every individual and every department require. Our experienced planning engineers are at your service to help select the best arrangements for your needs.

Hamilton De Luxe Auto-Shift Tables
Scientifically seasoned drawing surface; concealed mechanism controlling height and slope flexibility, can be moved with fingertip pressure; linoleum-covered reference surface. Many functional features, combined with prestige styling. Front table, basic table, and rear reference desk—matched styling.

Hamilton CL 100 Series
Entirely new, canted-leg styling assures stability without side crossrails. Strata-Core board, with green linoleum surface, both sides steel edged; tilts 0° to 40°. Fully adjustable recessed footrest; steel reference, tool, and catalog drawers. Other fine features, superb styling in light Sahara-Tan, satin-chrome hardware.

Hamilton L-Contour Unit
Counterbalanced, range of board adjustments permits frequent position changes—at finger touch—offering greater flexibility of work arrangement, lessening fatigue. Telescoping legs adjust height 30″ to 31″. Generous storage facilities, durable linoleum reference surface. Beautiful utilitarian styling, maximum space efficiency, constructed for long service.

Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems

This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-HL160. Eugene Dietzgen Co., Chicago 14, Illinois

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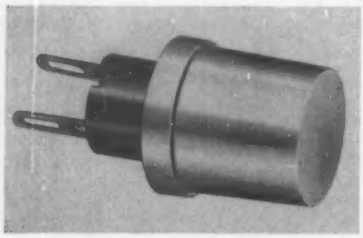
Circle 488 on Page 19



clear. Bulb is a G-3½ type two-pin unit. **Elotec Corp.**, 1425 N. Lidcombe, El Monte, Calif.

Circle 633 on Page 19

Potting Compound

for temperatures from −55 to +280 C

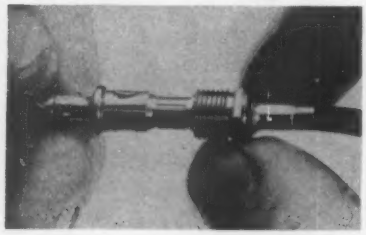
Isochemsilrub 1160 is a low-viscosity, silicone reacting potting and encapsulating compound. It cures in about 30 min at room temperature to form a tough, strong, heat-resistant, rubbery, protective dielectric cushion. Product is stable from −55 to +280 C temperatures. It resists weather, moisture, ozone, dust, oxidation, and corrosive chemicals. Compound absorbs excessive mechanical shock or vibration, and has good heat-transfer properties. **Isochem Resins Co.**, 221 Oak St., Providence 9, R. I.

Circle 634 on Page 19

Coaxial Connectors

in a variety of mounting configurations

Solderless, coaxial, crimp-type connectors are available in a variety of mounting configurations including snap-locking versions. Male and female connectors can be mounted interchangeably, and mated length is 1 13/16 in. Working voltages are 1000 v max at sea level and 500 v max at 60,000 ft. Life is 5000 matings, minimum, without electrical deterioration. Tensile strengths of the crimps exceed breaking strength of cable. Use of hard, gold-plated beryllium copper and TFE plastic assures high reliability. **Microdot Inc.**, 220 Pasadena Ave., South Pasadena, Calif.

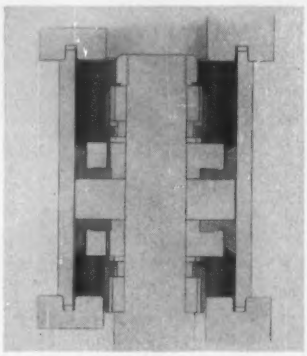


Circle 635 on Page 19

High-Speed Cushion

for hydraulic cylinders

High-speed, self-regulating, floating cushion is available throughout complete line (1½ through 14-in. bores) of hydraulic cylinders. Cushion permits faster cycling than before possible on cushioned hydraulic cylinders. In high-speed cycling, cushion plunger also acts as an extra-large check valve that allows comparatively large volumes of fluid to enter cylinder around piston rod. This speeds up the start of cylinder stroke in coming out of the cushion and eliminates the ball-check assembly. Cushion plunger has a thin-wall,



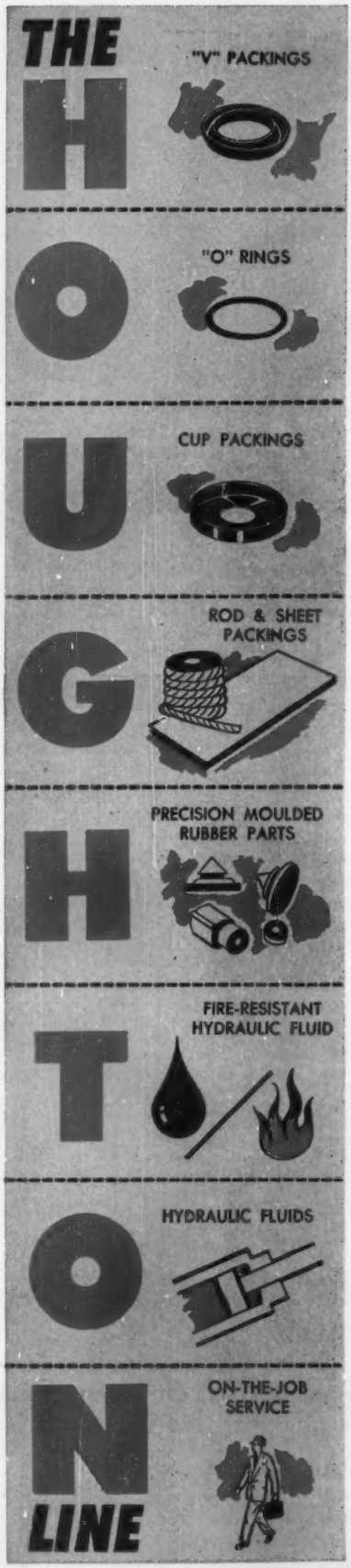
floating sleeve which automatically adjusts itself to trapped pressure under varying deceleration conditions. Shock and pounding are eliminated because, as trapped pressure rises, sleeve compression increases to provide greater plunger clearance. For slow-speed cycling, sleeve automatically readjusts to full diameter to keep clearances to a minimum. **Miller Fluid Power Div., Flick-Reedy Corp.**, 7N015 York Rd., Bensenville, Ill.

Circle 636 on Page 19

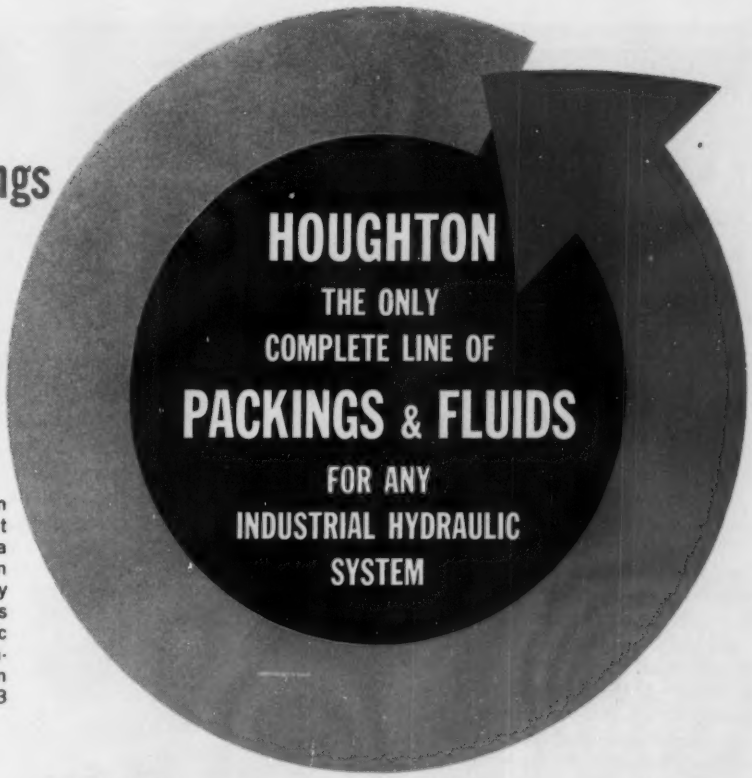
Die-Stamped Circuits

are consistently uniform and reliable

Die-stamped circuits are made by die cutting the conductor pattern from metal foil coated on one side with a thermoresponsive adhesive, and simultaneously bonding circuit



How to select COMPATIBLE Packings for fire-resistant hydraulic fluids!



Use this handy guide for your protection in selecting packings for fire-resistant hydraulic fluids. It's your guarantee of a completely unbiased recommendation . . . for it comes to you from the only manufacturer who makes both packings and fluids for any industrial hydraulic system. For details or help on any hydraulic packing problem, call your Houghton Man, or write: E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

TYPE OF FIRE-RESISTANT HYDRAULIC FLUID	COMPATIBLE PACKING COMPOUNDS*	HOUGHTON PACKING BRANDS
Water-Glycol	Homogeneous Buna N	Vix-Syn 10V70—O-Rings and U-Cups; Vix-Syn 10V90 "V's"
HOUGHTO-SAFE 600 Series	Fabricated Neoprene	Vix-Syn 3081 Cups and 1081 "V's"
Phosphate-Ester	Homogeneous Butyl	Vix-Syn 10V70-132 O-Rings and U-Cups; 10V85-94 "V's"
	Fabricated Butyl	Vix-Syn 3067 Cups and 1067 "V's"
HOUGHTO-SAFE 1000 Series	Leather-Impregnated with Polysulfide	Vim Leather No. 1243 Cups, "U's", "V's" and Flanges
	Leather-Impregnated with Wax	Vim Leather No. 1231 Cups, "U's", "V's" and Flanges
Water-Oil Emulsion	Homogeneous Buna N	Vix-Syn 10V70 O-Rings and U-Cups; 10V90 "U's"
	Fabricated Neoprene	Vix-Syn 3081 Cups and 1081 "V's"
HOUGHTO-SAFE 5040 Series	Leather-Impregnated with Polysulfide	Vim Leather No. 1243 Cups, "U's", "V's" and Flanges
	Leather-Impregnated with Wax	Vim Leather No. 1231 Cups, "U's", "V's" and Flanges

*Under certain conditions of temperature, pressure or chemical composition, special packing materials may be necessary. When in doubt, consult your Houghton Man first.

E. F. HOUGHTON & CO.

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Circle 489 on Page 19

No. 19 of a series

Eastman 910 Adhesive solves another production bottleneck

Templet Industries, Inc., Brooklyn, N. Y., produce steel-rule stamping dies that can cut through 1-inch steel plate.

Neoprene ejector springs, conforming to the shape of the die, are mounted alongside the steel rules on the base plates. Bringing the dies together compresses the neoprene. When the dies are released, the neoprene expands to its original thickness, ejecting the stamped part and the scrap.

Needed was a simple method of securely bonding the neoprene to the metal and wooden base plates. The answer? Fast-setting, high-strength Eastman 910 Adhesive. The bond it makes holds for the life of the dies, which can run to more than 250,000 stampings.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

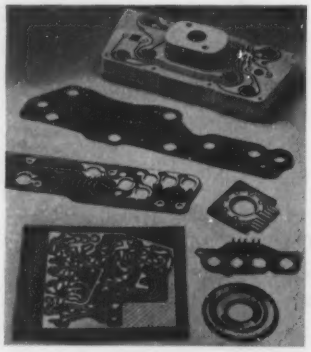
Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials strong bonds are made within minutes.

What production or design problems can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9111 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-11, Kingsport, Tenn. (Not for drug use) *See Sweet's 1960 Prod. Des. File, 7/E*

Circle 490 on Page 19

to insulating base material under heat and pressure. Circuits are available for a variety of automotive, appliance, and control applications, and also have use in instruments, computers, television sets, toys, and other products requiring electronic and electrical circuitry. Die-stamped circuits provide savings of 10 to 40 per cent over etched units. Tolerances can be held to 0.003 in. Circuits are supplied in a variety of base materials without regard to their resistance to etchants. In addition to the usual laminated plastics, these include vulcanized fiber and thermosetting and thermoplastic molded materials. Any metal to



which adhesive can be applied can be used for the conductor, although copper is almost always specified. Other available conductor metals include aluminum, brass, silver, gold, Nichrome, phosphor, bronze, plated metals, and steel alloys. **Dytronics Inc.**, 115 Main St., Rochester, Mich.

Circle 637 on Page 19

Wire Ties and Clamps

plastic units have high strength

New line of plastic wire ties and cable clamps is now available. Polyethylene wire ties combine strength, durability, and simplicity of application in bundling groups of wire and similar harness applications. Ties are easily removed to speed repair or to add more wires without disturbing tie or group of wires. Made from nylon Zytel 101 or high-dielectric polyethylene, ties are chemically inert and heat resistant. Breaking points range from 45-95 lb. They are available in 4-in. length in red, blue, and yellow

The quickest most practical way to put strong threads in soft materials the TAP-LOK® INSERT

SLOTTED

IN SOFTER METALS AND PLASTICS... Has full V-form external threads to provide maximum locking torque and permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings and plastics. Meets requirements of MIL-MS-35914.

H-SERIES

FOR HIGHER STRENGTH MATERIALS... Has heavy wall and truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.

P-SERIES

FOR SPARK PLUG SOCKETS ... Designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. Available from stock for standard plug sizes to meet most common needs.

W-SERIES

FOR WOOD... Has coarse pitch external threads offering maximum strength in combination with ability to be driven into thin sections without splitting them. For furniture, cabinets and other wooden parts where strong, permanent threads are needed, or that are frequently assembled and disassembled.

Another fastener development from –

TAP-LOK GROOV-PIN CORPORATION

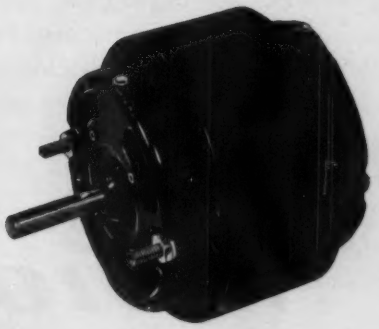
1130 Hendricks Causeway, Ridgefield, N. J.

Circle 491 on Page 19

CONSTANT SPEED AND TORQUE OF **EMERSON ELECTRIC MOTORS**

is assured by balanced Die-Cast Rotors

The precision tolerances of the rotors in Emerson Electric Motors insure a uniform air gap for constant speed and torque. Noise and vibration are kept to a minimum by the symmetrical rotor design that provides a porous-free casting. The rotor is supported on each side to decrease the bearing load and give your application long, trouble-free operation.



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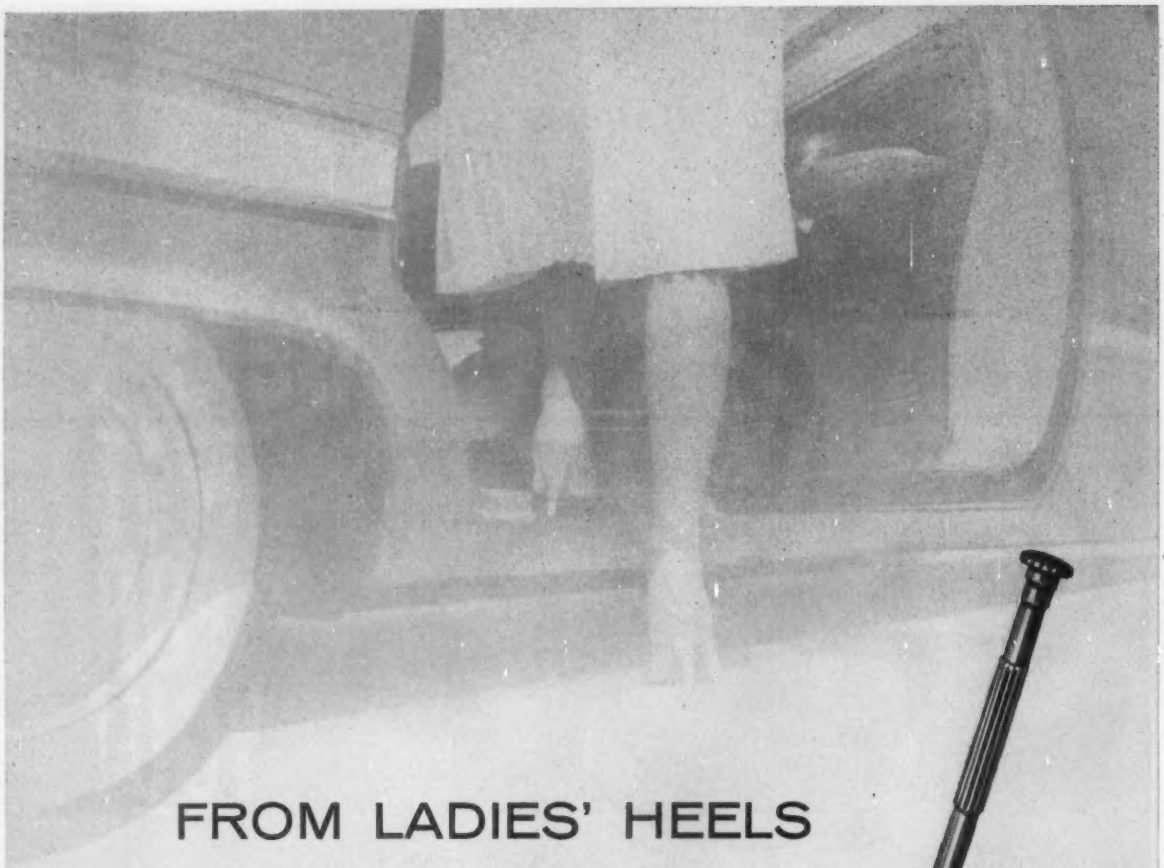

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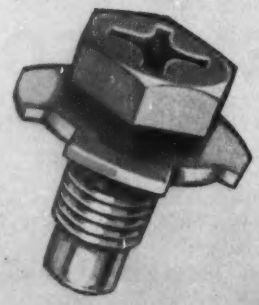
Whether your products are shoes or automobiles . . . whether your needs for special-purpose fasteners are heel nails or screw and washer assemblies . . . look to National Lock. Diversified, flexible equipment coupled with experienced design engineers make possible the manufacture of both unique and standard fastener products. Next time, let National Lock help you solve your fastener problems.



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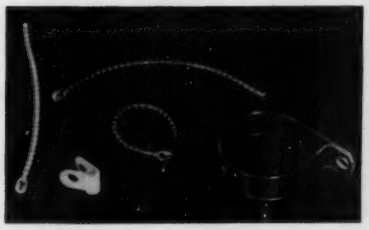


for color coding. Cable clamps of the same material are lightweight, chemically resistant, and combine toughness with excellent electrical properties and shock resistance. They are effective at a temperature range of −60 to +300 F. **Nylogrip Products**, 570 Pleasant St., Watertown 72, Mass.

Circle 638 on Page 19

O-Rings

are available in sizes over 6-in. diam

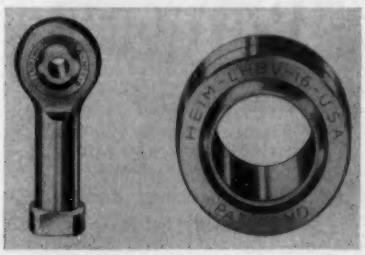
New molded O-rings are furnished in two standard cross sections, 0.139 in., ±0.004, and 0.275 in., ±0.006. Rings are available in any specified diameter over 6 in. A variety of elastomers is used for service in almost all types of hydraulic media. **Kalendex Div., Periflex Inc.**, 1791 E. Ten Mile Rd., Madison Heights, Mich.

Circle 639 on Page 19

Bearings, Rod Ends

are lined with Teflon woven fabric

Rod ends, either male or female threaded, and plain spherical bearings are now available, lined with Teflon woven fabric. Bearings with Teflon bearing surface provide high load ratings, self-alignment, and simplicity of asssembly, plus long-wearing, low-friction, self-lubricating, high-impact properties of TFE fluorocarbon fiber. Inseparable bonding of fabric to sub-



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Better Prints Due to Perforated Rollers!

Better, faster, more economical prints are what you get as a result of these perforated stainless steel rollers . . . a patented exclusive feature you'll find only in Revolute whiteprinters. The holes allow practically 100% exposure to the developer—at high speeds, low speeds, or fluctuating speeds. Prints travel a shorter route, come through clearer, faster, and there's ¼ to ½ less ammonia consumption than in other designs.

This is just one of the many important advantages in a Revolute Star that pays off for you in more efficient, economical performance. Moreover, you'll find a Star model to meet your printing needs exactly. Printing widths of 24", 42" or 54"; top speeds of 45 or 75 fpm.

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Circle 494 on Page 19

strate, and positive mechanical interlock between Teflon liner and outer member of bearing, insure against float or breakaway. Wide range of sizes and materials is available. **Heim Co.**, Dept. MD, Fairfield, Conn.

Circle 640 on Page 19

Variable Torque Limiter

disengages power on overload and jam-up

Torque-Master XB-150 prevents damage to motors and drives by instantly disengaging power upon overload and jam-ups. Interchangeable bushings are used from ½ to 1 7/16-in. bores. Single, double, and triple-groove sheaves and sprockets fit without machining. Timing-belt sheaves and rotating

members are easily mounted. Unit can be adjusted manually to release at any predetermined torque setting from 10 to 150 lb-ft, or can be locked in positive drive with no release. Limiter acts as an automatic shear-pin mechanism, slipping only when a jam-up occurs and re-engaging when overload is relieved. Torque output remains constant when exposed to changing temperatures, weather, oil, and abrasive conditions. **Torque-Master Div., Roberts Aircraft Engine Co.**, 203 N. Lake St., Burbank, Calif.

Circle 641 on Page 19

Self-Cleaning Valve

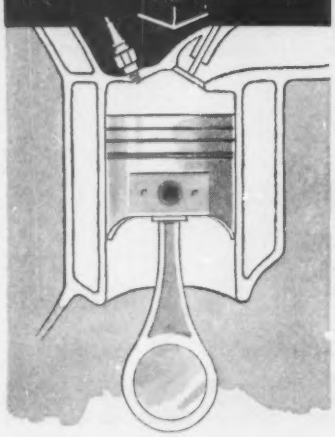
has 10,000 psi working pressure

Made in a variety of models—two, three, and four-way with closed and open centers—new valve has a working pressure of 10,000 psi, withstands 15,000 psi surge, and has a burst pressure of over 30,000

ENGINE DESIGNERS

ENGINEERS

MANUFACTURERS



KNOW YOUR

PISTONS

Do you know that a set of Gillett & Eaton Oil Absorbing Vanasil pistons ran more than 2500 hours in a heavy duty tractor *without any increase of blow-by?* This is a 40% increase in life over standard pistons.

In addition to Oil Absorbing Vanasil pistons, G & E makes tested and proven Aluminum Alloy, Hi-Tensile Iron, Bi-Metal and Insert Types in all sizes. Write for information on the performance you can expect from each type.

GILLETT & EATON, Inc.

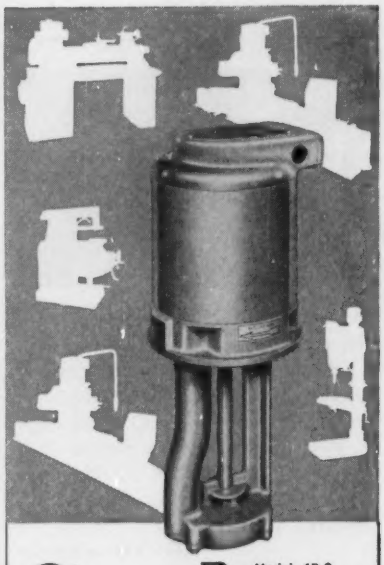
860 Doughty Street, Lake City, Minn.

Sold in Canada by
Gould National Batteries of Canada, Ltd.
Fort Erie, Ontario

Piston and casting specialists

Established 1868

Circle 495 on Page 19



Model 6P-3

Gusher

CHOICE OF THE LEADERS AT THE MACHINE TOOL SHOW

For years the leading machine tool builders have chosen Gusher Coolant Pumps as the heart of their coolant system. They know from experience that Gusher Coolant Pumps are precision built, efficient in operation, and give long trouble-free life with minimum maintenance.

Now again at the recent Machine Tool Show, Gusher Coolant Pumps were installed as O.E.M. on many of the leading machine tools. So follow the leaders, specify Gusher Coolant Pumps on your metal cutting machines.

Write for our **FREE** Condensed Catalog and New Tank Unit Bulletin 61A

THE **Ruthman** MACHINERY CO.

- COOLANT PUMPS
- CIRCULATORS • AGITATORS
- MOLTEN METAL PUMPS

1811 Reading Road
Cincinnati 2, Ohio

Circle 496 on Page 19

Let a J-M friction specialist help you solve complex "stop and go" problems

J-M SMALL MOLDED PARTS, MANY FEATURING UNITIZED CONSTRUCTION, ARE CUSTOM-DESIGNED TO YOUR EXACT NEEDS

One sure way to improve performance in small brakes and clutches is to call on the free advice of a Johns-Manville Friction Specialist. He's an expert in the design and construction of small parts that increase efficiency in "stop and go" actions. He is prepared to discuss your specific problems...and, where conditions permit, work J-M's unitized construction into your plans.

At his command is a wide range of asbestos-based friction materials, especially developed for small molded parts. These organic compositions meet virtually any requirement. If, for example, you need drive clutches, torque limit clutches, or small brakes – J-M MINI-BLOKS® are made of ideally suited materials. Precision-molded MINI-BLOKS offer high friction, light weight, high temperature resistance, and a long service life that is free of trouble.

The advice and help of a Johns-Manville Friction Specialist are yours for the asking. Just tell him the part you need and the characteristics you require. He'll take it from there. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario. Offices throughout the world. Cable address: Johnmanvil.

JOHNS-MANVILLE

Circle 497 on Page 19

NEW FRACTIONAL HORSEPOWER SPEED-TROLS

Infinitely variable speeds from 4660 to 1.2 rpm; 10 to 1 variation, ¼, ½, ¾ horsepower ratings

COMPACT

WHERE IT COUNTS...

AND LIGHTER TOO

The new Sterling Fractional Speed-Trol has the shortest over-all length dimension in the industry and is up to 15% lighter than competitive units.

The new Fractional Speed-Trol retains the rugged durability famous in the Sterling line of integral variable speed drives and features larger pulley diameters for a cooler running, longer lasting belt.

The new fractional unit may be foot mounted in any position, shaft low or shaft high, case upright or horizontal, shaft horizontal, vertical or "C" Flow or can be furnished with Type C bracket for face mounting directly to machinery. Important NEMA standard dimensions for shaft height and diameter are retained to permit substitution with standard motors.

The Fractional unit is available in single phase, three phase; drip proof, totally enclosed, explosion proof.

New Fractional Speed-Trol is a variable speed gear motor, too.

Get the full story about the new Sterling Fractional Horsepower Speed-Trol, write for Bulletin # 201.

STERLING
ELECTRIC MOTORS, INC.
A Subsidiary of Hathaway Instruments, Inc.
5401 TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA

Offices and stocks in all principal cities.
Over 400 distributors throughout the country to serve you.

psi. It has heavy, one-piece, stainless-steel body construction with noncorrosive internal parts. Valve is available for air, water, and oil services. Lo-Torq sliding seals and selector disc are stainless steel, honed optically flat for tight sealing. Seals are wear-compensating, sealing tighter as they wear in. Valve is self-cleaning as seals wipe across the selector disc, removing foreign matter. Slight area differential unbalance on the seals prevents excessive turning torque at

high pressures and causes the sealing force to increase as service pressure rises. Valve is available in sizes ¼ to 1 in., with choice of internal pipe, or internal straight (gasket seal) threads as standard. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 35, Ohio.

Circle 642 on Page 19

Miniature Potentiometers

are humidityproof units

Models 50 and 60 trimming potentiometers are ⅜ and ½-in. square respectively. Humidityproof construction is accomplished by incorporating an internal retainer for the adjusting screw. Screw is sealed with an O-ring and the cover with a pressure gasket. By providing greater surface contact between mandrel and aluminum case, heat is easily dissipated without the use of an external heat sink or additional hardware. Dual-wiper design provides positive contact under all conditions of shock and vibration. Teflon insulation is standard on stranded-wire-lead types. Model 50 is available in ranges from 50 to 20,000 ohms and Model 60 from 50 to 50,000 ohms. Model 50, weighing 1 gram, is rated at 1 w at 50 C; Model 60, weighing 2 grams,

For mere pennies you insure yourself *and your customer* against damage to your products during shipping, storage, processing. The economic facts are that simple.

S. S. White rigid acetate **Quality Line,** plastic protectors absorb blows like a Champion Heavy-Weight. Impervious to acids, alkalies, greases and oils, they seal in fluids, seal out dirt, dust, and anything else that might damage expensive equipment. Note this too... they remove *by hand* in a matter of seconds... and leave no shreds behind.

For even lower cost protection, look into S. S. White **Economy Line** elastic vinyl protectors. A good shock-absorbing, rubber-like material with a non-slip grip that makes removal a snap. Stays put too. Customers like this; saves them hours of production time.

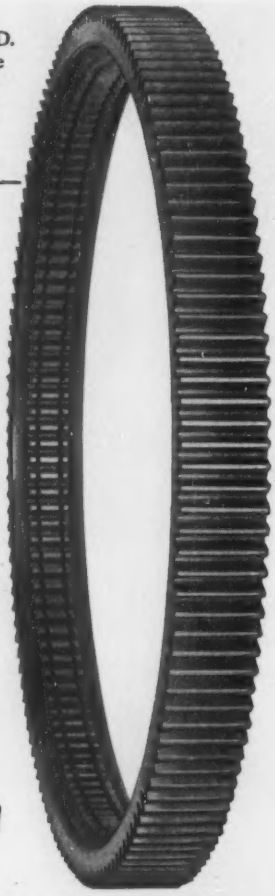
Start buttoning up customer good will today...

WRITE FOR FREE BULLETIN
P5708 and Samples

S.S.White **PLASTICS DIVISION**
Dept. 4P, 10 East 40th Street, New York 16, N.Y.

Circle 499 on Page 19

Snap-ring grooves in this 12" O. D. thin-section *Reduction Drive Gear* are machined before carborizing and hardening. Both spline and gear teeth are ground and held to .001" excentricity after hardening the entire gear.



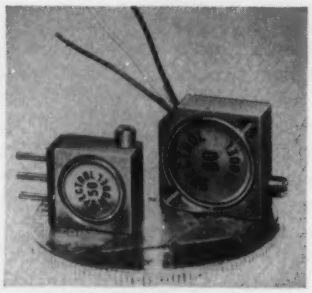
When you DRIVE for profits, GEAR with PERKINS

MACHINE AND GEAR CO.
Dept. 83 West Springfield, Mass.

Men who *know* will tell you that custom precision gears made by Perkins can eliminate many design, production and maintenance headaches — literally help you drive for better profits. When you want precision gears in experimental or production quantities, chances are you'll save time and money by checking with Perkins first. What is your gear problem today?

This Handy Gear Calculator, easy to use, saves time. *Folder* illustrating Perkins custom precision gears and facilities offers information. Both yours on request.

Most machining operations on this *Drive Gear Shaft* are performed after localized hardening with the cored areas at Rockwell C42. External spline and gear teeth are ground with splines held to precision tolerances.



is rated at 2 w at 40 C. Both units are available in a number of different terminal types and adjustment-screw configurations. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif.

Circle 643 on Page 19

Integral-Horsepower Motor

is extremely lightweight

Standard integral-horsepower motor incorporates aluminum-alloy in place of conventional cast-iron construction, achieving weight reductions of up to 30 per cent over cast-iron motors on a rating-for-rating basis. Other advantages of the aluminum construction include improved heat transfer for cooler running, and maximum resistance to rust and corrosion. Motor frame, end bells, bearing caps, rotor, and conduit box are all made of aluminum alloys. Bearings are prepacked and double shielded. Contaminants are positively excluded from the bearing by a special labyrinth seal on the shaft. Chamber adjacent to the bearing housing contains an extra reservoir of grease, eliminating the need for regreasing. Voltage change is simplified on all dual-voltage motors with built-in, quick-connect terminal board, located in large conduit box. Space is also provided in the conduit box for protection de-

M-U-L-T-I C S-P-E-E-D

CONSTANT

Constant Torques — *Constant hp*

Variable Torques — *2, 3, 4 speeds*

- ¼—100 hp, a. c.
- 3 or 2 phase
- 2, 3, 4 speeds
- 3600 down to 450 rpm

USES LIKE THESE
- Blowers, fans
- Conveyors
- Elevators
- Machine tools
- Pumps

Write for Bulletins 1005, 1015.

Make you dizzy? Needn't! But . . . you may find a Howell *Multi-Speed* to be just the motor you need.

For years, Howell Multi-Speeds have proved ideal where motors must run at more than one speed, but don't have to provide variations in speed.

Your HOWELL MAN will give you expert application assistance. Call him! A-2914A

HOWELL
electric motors company
Offices in principal cities . . . see YELLOW PAGES

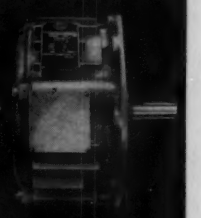
Circle 501 on Page 19

Cut space, weight, up to **1/2** *with*

FLAT TYPE

motors

New!



¼—10 hp
TENV
or
TEFC

Send for Bulletin 1065 (A-B)

Do you have motor space and (or) weight problems? If so, we have just the motor answer you need.

Howell flat-type motors are as much as 48% shorter and 50% lighter-weight than conventional motors of the same ratings. Ideal for such applications as punch presses, metal shears, milling machines, drill presses, many others where space, weight are at premium. A product of *The Leland Ohio Electric Company, Dayton, Ohio* . . . A Howell subsidiary. A-2933A

HOWELL
electric motors company
Offices in principal cities . . . see YELLOW PAGES

Circle 502 on Page 19

Jobs Wanted—Motor Maker

HOWELL WANTS TO WORK FOR YOU

No job too big, too small . . . 1/40-300 HP, A.C. MOTORS

We work hand-in-hand *with* and *for* many of America's leading makers of motor-driven machines and appliances.

We supply top-quality motors, gearmotors, speed reducers, generators . . . *and* we back them with top-notch development, manufacturing, application assistance . . . customer-serviced by men known for cooperation, ability, integrity.

If you're not one of our fast-growing number of "Customer Bosses," we'd like to work for you, too. Call your HOWELL MAN!

A FEW PRODUCTS OF FIRMS WE WORK FOR:

- Conveyors
- Blowers
- Business machines
- Compressors
- Fans
- Floor polishers
- Machine tools
- Pumps

A-2919A

HOWELL•LELAND MOTORS drive 70% of all U.S. gasoline pumps

HOWELL•K-C makes 11 leading private-brand bench grinders

HOWELL is a leading maker of motors for punch presses

HOWELL•K-C, a big-volume maker of floor-polisher motors

HOWELL
electric motors company
Offices in principal cities . . . see YELLOW PAGES

Circle 503 on Page 19

• *fourth of a series*

WHAT YOUR HOWELL MAN represents and has to offer

Greetings, again, from the "New Howell" . . . a report to the thousands of customers and other friends who have helped us grow.

Our *corporate* and *product* "Images" have changed vastly in the past few years.

Howell now also offers you the combined broad motor lines of: *The Ohio Electric Mfg. Company; Kingston-Conley, Inc.; The Leland Ohio Electric Co.*

Each is a leader in certain important areas. Each is known for certain outstanding products. Each has built on ideas, initiative, integrity.

Consolidation is now completed. *People, Plants, Products* of four formerly separate enterprises are now ONE COMPANY . . . dedicated to continued high standards of service to American Industry.

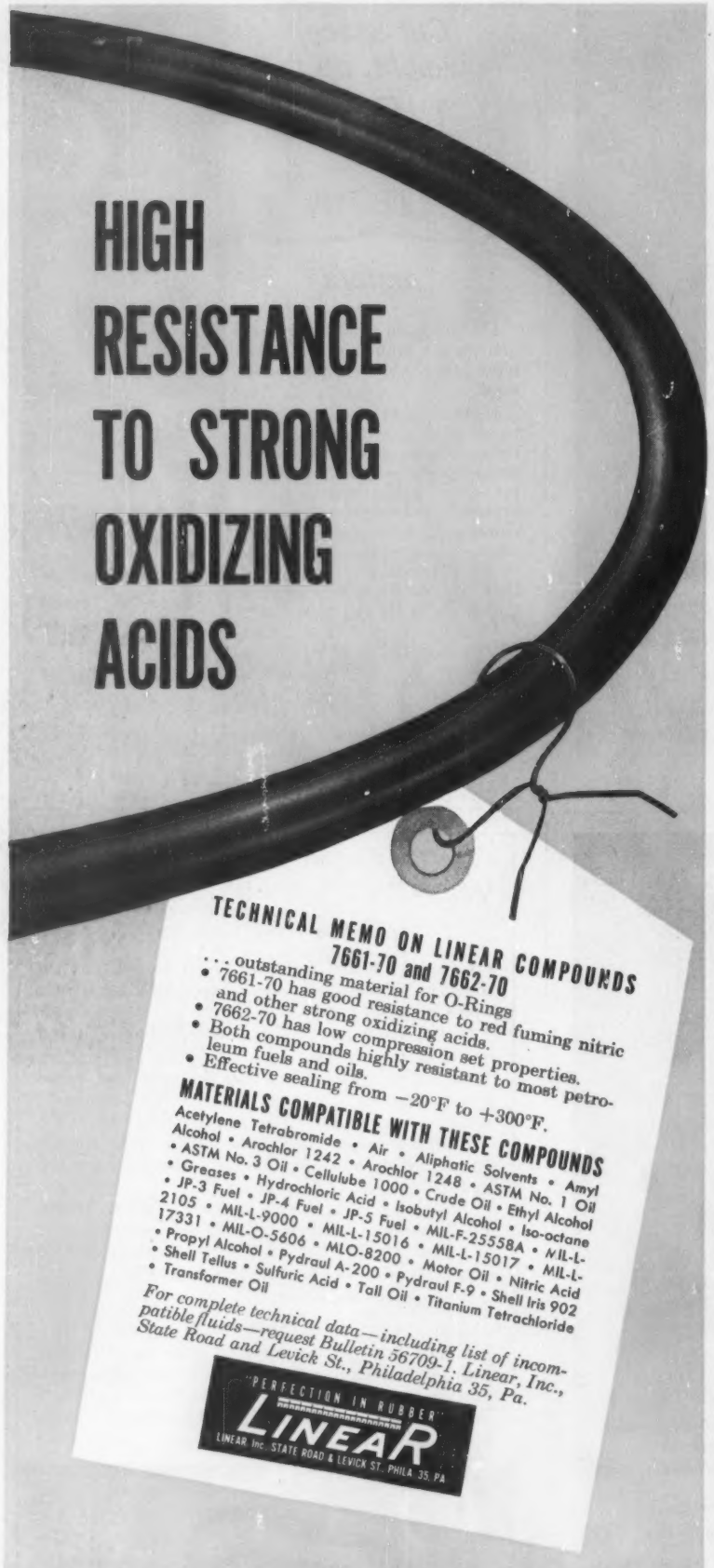
A few words about our:

craftsmanship

Howell quality has been a tradition since 1915. Only high-grade materials are used. Closest attention is paid to smallest details. Tests are exacting. Rigid quality-controls. Above all Howell products are made by *fine craftsmen.* A-2933A

HOWELL *electric motors company*
SUBSIDIARIES:
OHIO ELECTRIC MFG. COMPANY • LELAND OHIO ELECTRIC COMPANY • KINGSTON-CONLEY, INC.

Circle 504 on Page 19

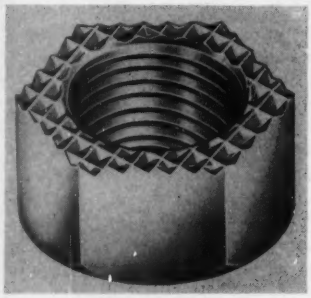

HIGH
RESISTANCE
TO STRONG
OXIDIZING
ACIDS
TECHNICAL MEMO ON LINEAR COMPOUNDS
7661-70 and 7662-70
. . . outstanding material for O-Rings
• 7661-70 has good resistance to red fuming nitric and other strong oxidizing acids.
• 7662-70 has low compression set properties.
• Both compounds highly resistant to most petroleum fuels and oils.
• Effective sealing from −20°F to +300°F.
MATERIALS COMPATIBLE WITH THESE COMPOUNDS
Acetylene Tetrabromide • Air • Aliphatic Solvents • Amyl Alcohol • Arochlor 1242 • Arochlor 1248 • ASTM No. 1 Oil • ASTM No. 3 Oil • Cellulube 1000 • Crude Oil • Ethyl Alcohol • Greases • Hydrochloric Acid • Isobutyl Alcohol • Iso-octane • JP-3 Fuel • JP-4 Fuel • JP-5 Fuel • MIL-F-25558A • MIL-L-2105 • MIL-L-9000 • MIL-L-15016 • MIL-L-15017 • MIL-L-17331 • MIL-O-5606 • MLO-8200 • Motor Oil • Nitric Acid • Propyl Alcohol • Pydraul A-200 • Pydraul F-9 • Shell Iris 902 • Shell Tellus • Sulfuric Acid • Tall Oil • Titanium Tetrachloride • Transformer Oil
For complete technical data—including list of incompatible fluids—request Bulletin 56709-1. Linear, Inc., State Road and Levick St., Philadelphia 35, Pa.
PERFECTION IN RUBBER
LINEAR
LINEAR, Inc. STATE ROAD & LEVICK ST. PHILA. 35, PA.

vices such as manual or automatic-reset, thermal-overload protectors. Motors are available in both single and polyphase. **Franklin Electric Co. Inc.**, Dept. 161, Bluffton, Ind.

Circle 644 on Page 19

Lock Nut

for slotted-angle applications



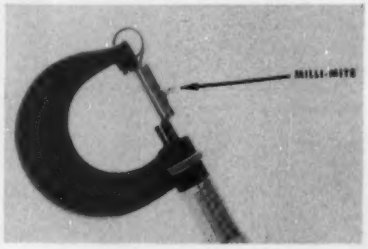
Waffle Face lock nut is produced by a cold-headed process for high strength and quality. Nut is used extensively in steel shelving and slotted-angle applications. It is available in all commercial sizes in steel, brass, aluminum, and stainless steel in all finishes. **Jacobson Nut Mfg. Corp.**, Box 177, Kenilworth, N. J.

Circle 645 on Page 19

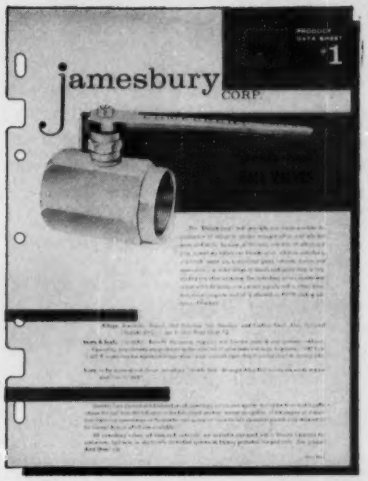
Inertia Switch

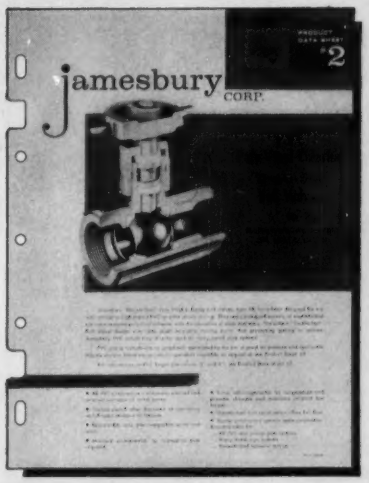
for temperatures from −65 to +200 F

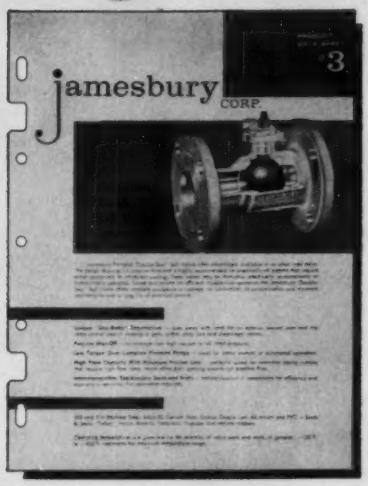
Miniature inertia switch, Model 6UO-200, is accurately preset to respond to acceleration forces to 250 g within a tolerance of ±15 per cent of setting. It incorporates only one moving part, a precision-ground steel ball held against a solid base by a uniform magnetic field. When opposing force of acceleration exceeds magnetic force, ball moves to close a normally open electrical contact. Switch meets all environmental specifications of



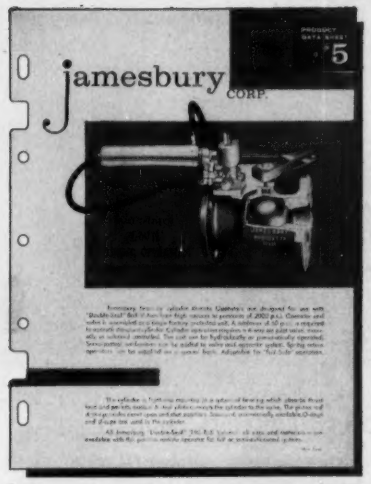
Yours For The Asking!

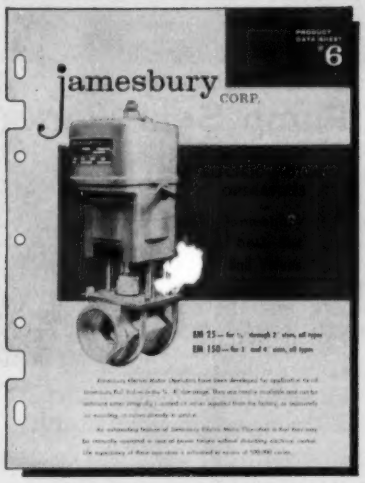


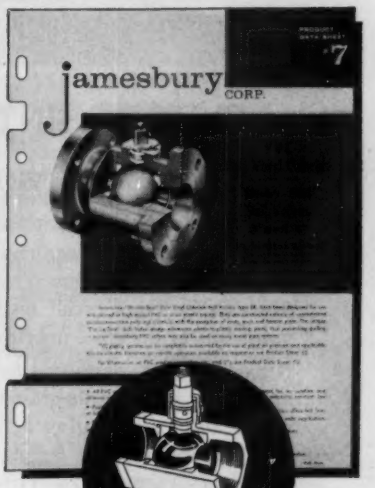


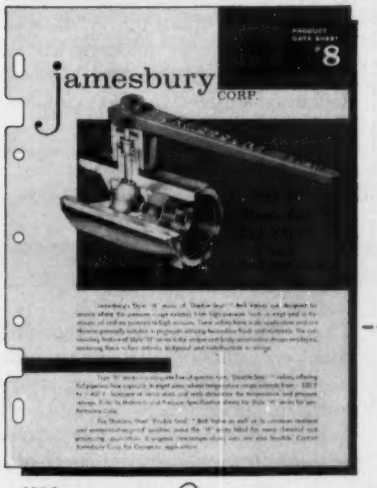


FACTUAL DATA









on jamesbury* BALL VALVES

AS VERSATILE AS INDUSTRY ITSELF

Get the full story on Jamesbury Corp.'s complete line of "Double-Seal" Ball Valves and accessories. Learn why the Jamesbury "Double-Seal" Ball Valve has been labeled "as versatile as industry itself". Get all the facts on materials, sizes, etc. They are yours for the asking: the facts about Jamesbury Corp. — the nation's foremost exclusive manufacturer of Ball Valves.

*Patented

JAMESBURY CORP.
NEW STREET, DEPT. PDS, WORCESTER, MASS.
Please send me the Data Sheets checked below.

#1 #2 #3 #5 #6 #7 #8

Name..... Title.....

Company.....

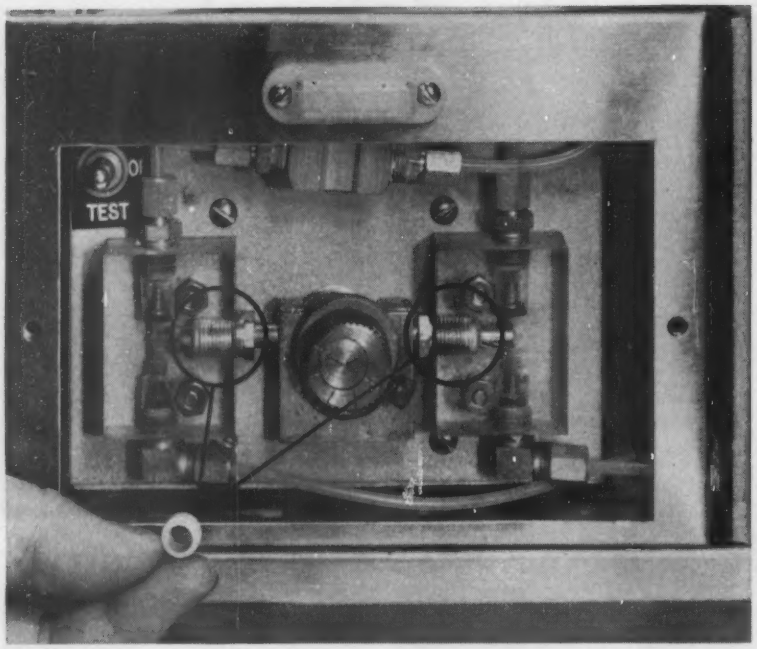
Address..... City..... State.....

126-0

JAMESBURY BALL VALVES
HELPING BUILD OUR NUCLEAR NAVY

JAMESBURY CORP., 61 NEW STREET, WORCESTER, MASS.

Distributors in Principal Cities



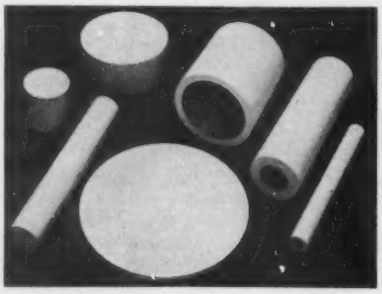
New FLUOROSINT* Pump Seal Works Where O-Rings and TFE Parts Fail

This double-piston miniature pump required a seal that would not expand in water, required no lubrication, was non-corrosive, and could be easily machined to close tolerances. The pump was used in commercial dishwashers, and the critical sealing point was in the rinse injector, shown above.

Rubber O-rings were tried first, but they quickly swelled in the hot, soapy water. Conventional TFE seals remained chemically stable, but reciprocating action of the steel shaft wore them down in one day.

FLUOROSINT, a new TFE fluorocarbon base composition, was the perfect solution. Precision rings machined from economical FLUOROSINT stock tubes, provided complete sealing and showed no signs of wear after months of intense testing.

FLUOROSINT is a unique plastic composition developed by Polymer to improve TFE's mechanical and thermal properties without materially affecting its excellent chemical and electrical characteristics. It is available in a variety of economical stock shapes (right) or as sintered (molded) parts.



For complete technical and application data, write for new illustrated Bulletin BR-9.

POLYPENCO* *industrial plastics*

*Polymer Trademark

Halex Corporation
A subsidiary of
The Polymer Corporation
Reading, Pa.
Export: Polypenco, Inc., Reading, Pa., U.S.A.

MIL-E-5272, including an operation range of −65 to +200 F. Switch can be utilized for control or limiting applications when actuated by acceleration, deceleration, impact, and/or shock. **Inertia Switch Inc.**, 311 W. 43rd St., New York 36, N. Y.

Circle 646 on Page 19

Perforated V-Belt

can be joined by new fastener and a screwdriver

New V-belting, available by the foot, can be joined by means of a new fastening device and an ordinary screwdriver. Joint is strong, and there is no need of special tools. Lack of metal-to-metal contact eliminates noisy vibration. Perforated belting has holes accurately punched

and centered on the surface. Steel fasteners are prebent to obviate bending stress. Belting is available in standard sections O, A, B, and C in full rolls or package assortments. It fits all standard sheaves. **Rockwood Pulley Mfg. Co.**, 20 Crosby St., New York, N. Y.

Circle 647 on Page 19

External Wrenching Bolts

have high strength-to-weight ratio

Twelve-point external wrenching bolts are available in high-tensile steel and high-temperature, heat-resistant materials. External wrenching head offers advantages in high torquing for greater preloads where required. Head accepts standard box and socket wrenches. Bolts meet requirements of MS9033 through MS9039 for high-temperature use and MS9088 through MS9152 for high strength-

Slots (or corrugations) prevent Fastenes from turning.
Sheet remains flush on opposite side. No swaged rim projects.
Clinching ring squeezes sheet material around back-tapered shank, securely locking Fastener.

PEM

The ORIGINAL Self-Clinching Fastener

Fifteen years ago Penn Engineering and Manufacturing Company introduced the self-clinching fastener, providing load-bearing threads in a wide range of—steel, aluminum, brass and copper sheets, "too thin to thread."

THE ANSWER TO PRODUCTION FASTENING

This unique, exclusive design was immediately recognized as the answer to production fastening by leading manufacturers of aircraft and missiles, automotive, electronic and communication equipment, business machines, farm machinery, electrical appliances, transportation equipment, vending machines, home appliances, etc. Stimulated the cost-conscious sheet metal assembly techniques utilized, today, by many of these manufacturers.

INSTALLED BY A SQUEEZE *With the Greatest of Ease* (without special tools)

Users tell us that—because the shank of PEM nuts acts as their own pilot . . . because, being round, they require no indexing . . . because they require no special tools . . . because several may be pressed into place in a single operation . . .

THEY SAVE THEIR COST MANY TIMES OVER

. . . in time, labor and special equipment. PEM nuts are one of the most profitable items in the assembly line.

Today, PEM Self-Clinching Nuts are made in six types for sheet thicknesses from .032 and up—in steel (with various rust resistant finishes), stainless steel, monel and aluminum. Sizes range from #0 to ¾". Also made as Blind Fasteners for pressure seal applications.

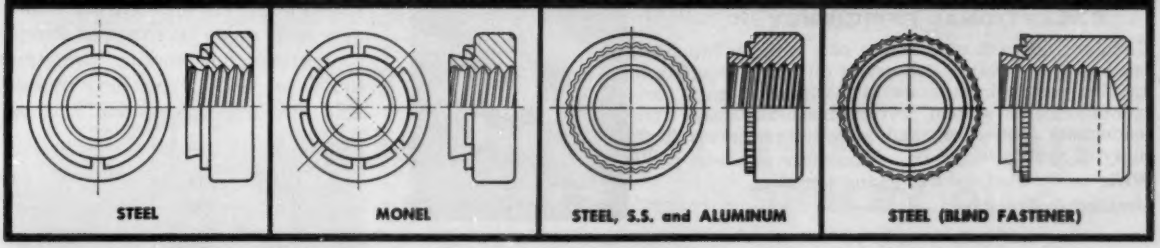
For complete information, write for Bulletin No. CL-960.

HIGH TORQUE AND PUSH-OUT RESISTANCE

. . . greatly in excess of assembly handling and screw torquing requirements, insure smooth, fast, uninterrupted fastening procedure. In service, under working load and vibration, torque and push-out resistance are not reliability factors, since the screw is always pulling the PEM Nut toward the sheet into which it is fastened.

The smooth *reverse* side of the sheet, with no swaged rim projecting, permits flush-tight assembly without need for clearance hole in attached part.

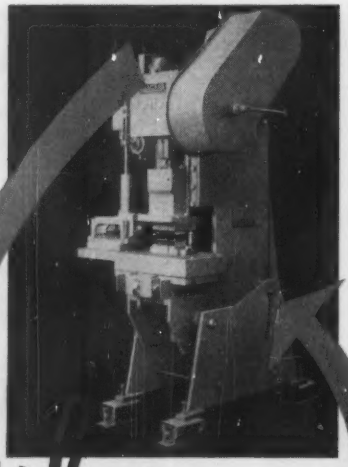
SIX TYPES OF PEM SELF-CLINCHING FASTENERS ANSWER MOST ALL REQUIREMENTS



PENN ENGINEERING & MANUFACTURING CORP., DOYLESTOWN • PENNSYLVANIA

New York (Belle Harbor, L. I.)—Neptune 4-7103
Cincinnati—Grandview 1-9011
Chicago (Forest Park, Ill.)—Forest 6-4971
Indianapolis—Clifford 1-4020
Detroit—University 3-5189
Milwaukee—Bluemound 8-6118
Toledo—Greenwood 4-9563
Dallas—Fleetwood 7-5713
Los Angeles—Bradshaw 2-8097
Miami—Tuxedo 5-3147
Minneapolis—Greenwood 4-6203

Circle 508 on Page 19



NEW!

Circulube

by BIJUR

A system of centralized, completely automatic machine lubrication with provisions for oil return

2-gallon Lubricators, Model CLFB continuous delivery; Model CLFC continuous AND cyclic delivery.

½ gallon Lubricator, Model CLWB continuous delivery.

Pressure Signal Switch, Model C-2512.

This new system continuously circulates clean, filtered oil through machine bearings at controlled rates. It also provides for filtering and removing contaminates from returned oil before recirculation.

WHAT IT DOES

Oil is pumped to bearings through the system, and returned through tubing or piping as advised by Bijur's engineering staff. Control-Units, installed at each bearing, control the flow of oil to that bearing.

Model CLFC has a dual pump which also permits cyclic oil delivery to certain bearings.

HOW IT WORKS

Basically, the Circulube system consists of a lubricator pump with reservoir and filter, a distribution system, and the control units at each bearing. The "brain" of the system is the Pressure Signal Switch. It prevents machine operation until proper oil pressure has been developed.

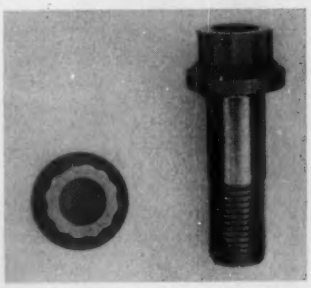
EXCEPTIONAL EFFICIENCY

Circulube offers three different new units, in two sizes, one supplying cyclical delivery of oil where required. It enables you to incorporate in machine design a foolproof lubrication system, prevents machine damage from inadequate lubrication, and provides maximum flexibility of application.

Write us for Bulletin CL, giving complete, detailed information.

BIJUR LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

2741



to-weight ratios. They are furnished in popular sizes and made to order for specific applications. **High Temperature Div., Mercury Air Parts Co. Inc.**, 9310 W. Jefferson Blvd., Culver City, Calif.

Circle 648 on Page 19

Miniature Tube Sockets

for high-frequency service in electronic equipment

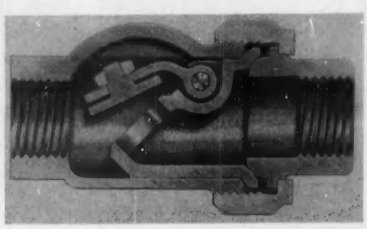
Chemelec 7 and 9-pin miniature tube sockets are available with saddles or shields. They are designed for high-frequency service in electronic equipment where low loss factor and dielectric constant are required. Body insulating materials are FEP Teflon or CTFE, excellent for high-frequency, high-temperature, and high-voltage service. Both materials exhibit excellent resistance to weathering and water absorption. Shield and saddle bases are steel, cadmium plated, or nickel-plated brass. Contacts are silver-plated beryllium copper. **Garlock Electronic Products, Garlock Inc.**, Camden 1, N. J.

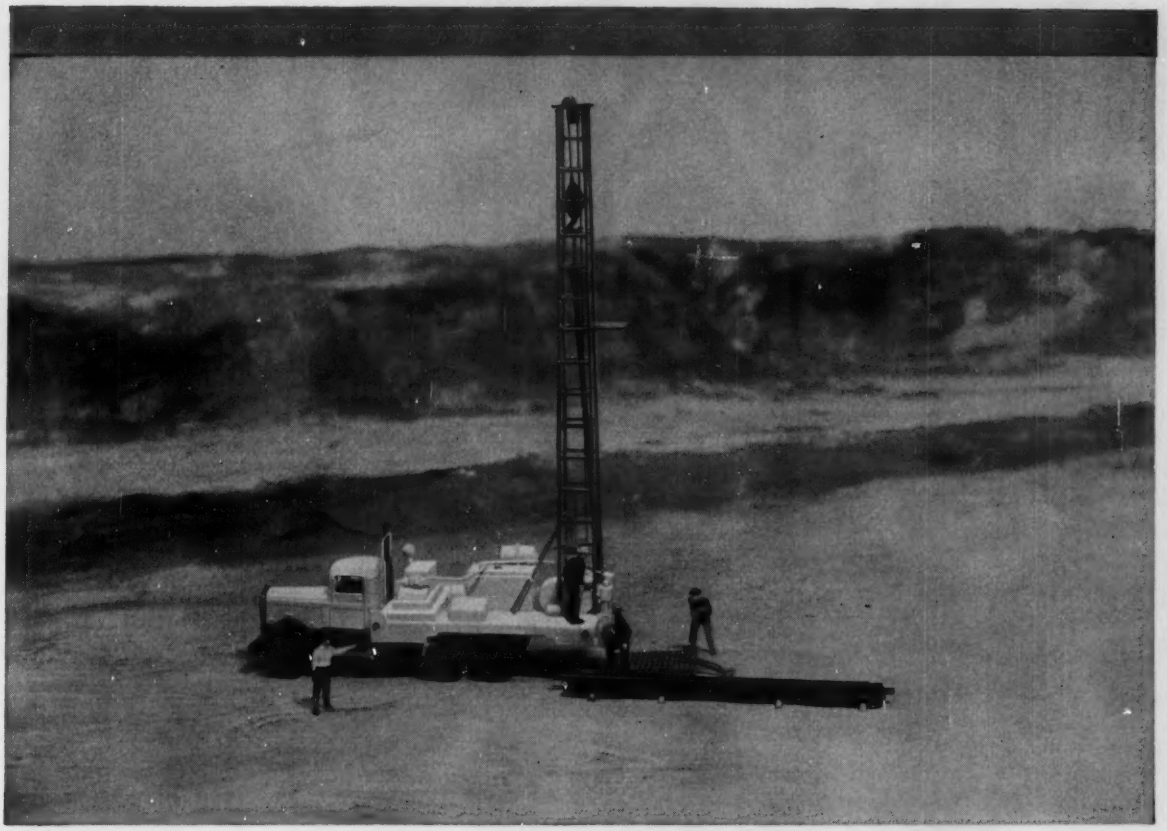
Circle 649 on Page 19

Check Valves

for working pressures to 250 psi

Union swing check valves are available with union or threaded flange connections for working pressures to 250 psi. Both types have renewable disc unit insert, and can be





Down-to-earth reasons for using Custom Quality OHIO Tubing

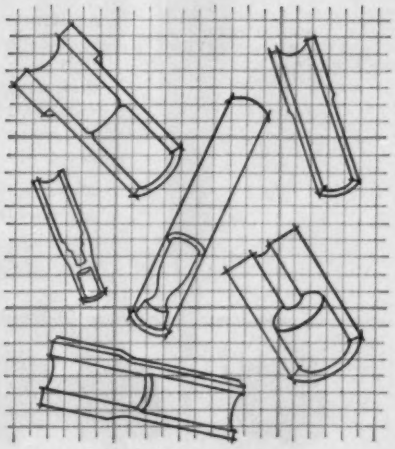
As in rotary drilling, which uses steel tubing internally upset by Ohio Seamless, greater strength and lighter weight may be important in your product.

So before selecting a tubing source consider these important facts. OHIO Tubing is always the exact tubing you need for your product because OHIO Tubing is CUSTOM MADE for your product. Your order is manufactured to your own specifications to produce steel tubing especially for your application — the precise grade, analysis, size, shape, special anneal and tolerances best suited to your needs.

Ohio Seamless Tube produces both seamless and electric welded steel tubing — is prepared to form many finished or semi-finished tubular parts to your designs.

To get the most from your next steel tubing order, use Custom Made OHIO Tubing. Contact your nearest Ohio Seamless representative, or send part drawings to the plant at Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America. A-3051A

Model illustrated built to 3.5 mm scale.



Typical Ohio Seamless tubular upset forgings

OHIO

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • **SHELBY, OHIO**

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Chattanooga, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Kansas City, Los Angeles (Lynwood), Miami, Moline, New York, New Orleans (Chalmette), Philadelphia (Wynnewood), Pittsburgh, Richmond, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita

EXPORT: [illegible] Steel Export Company, 220 Broadway, New York 7, New York

'Jeep'®
INDUSTRIAL ENGINES

ALL THESE ADVANTAGES AT NO EXTRA COST

POSITIVE VALVE ROTATORS
EXHAUST VALVE INSERTS
STELLITE OR EATONITE VALVES
100% COUNTERWEIGHTED, FORGED CRANKSHAFT
DEEP CHROME COMPRESSION RING
POSITIVE CRANKCASE VENTILATION

Only 'Jeep' Industrial Engines offer all these features as *standard equipment.* If you want the type of rugged performance that pays off in solid customer acceptance,—design with 'Jeep' Industrial Engines.

Write for specifications, power curves and pilot testing procedure.

'Jeep'-6 MBHP: 41-92

'Jeep'-4L MBHP: 22.5-59

'Jeep'-4F MBHP: 22.5-70

KAISER WILLYS MOTORS

WILLYS MOTORS, INC.
INDUSTRIAL ENGINE DEPT.
TOLEDO, OHIO

Manufacturers of -4 and -6 Cylinder 'Jeep' Industrial Engines

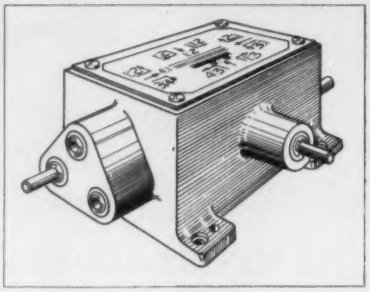
used in either horizontal or vertical installations. Precision-ground disc and seat assure tight closing under a fraction of an ounce of pressure, and permit maximum closing. Valves are available for pipe sizes from 1/4 to 2 in. **Flomatic Corp.**, Hoosick Falls, N. Y.

Circle 650 on Page 19

Gear Box

has 10 basic ratios

Universal multiratio gear box is designed as a developmental speed reducer and increaser. Having 10 basic ratios (5 reductions and 5 increases), it eliminates the need for a number of single-ratio units. Standardized mounting dimensions



insure quick and accurate assembly with all hangers, breadboard plates, and development components. Stocked in 1/8, 3/16, and 1/4-in. shaft sizes, with ball or oilless bearings, assemblies have less than 30 min backlash through the entire gear train. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y.

Circle 651 on Page 19

Torque Actuator

is available for light applications

Midget model Rotac torque actuator, having a body only 2 in. square and 2 in. long, is available for light applications. Unit is operated by hydraulic or pneumatic pressure to produce reciprocating rotary movement. Single-vane model produces rotation in a maximum arc of 270 deg. Movement of the double-vane model is restricted to 90 deg, but power is more than doubled. Applications include instruments, computers, calculating machines, switches, chemical controls, carton-

In the shape, length,
diameter you need:

ASARCON®

Continuous-Cast Bronze Castings

Asarco will custom cast practically all standard tin-bronze alloys in the shapes, lengths, and diameters you need. You get custom shapes in continuous lengths; uniformity and machinability of alloys guaranteed free of hard or soft spots, with no sand, dirt, or dross to dull tools or reduce cutting speeds. You get the superior physical characteristics of continuous cast bronze: impact, tensile, yield strength and hardness, as much as 100% better than the same alloys cast other ways. Write for complete data to Continuous-Cast Department, American Smelting and Refining Company, Barber, N. J. or Whiting, Ind.

Immediately available from stock:

ASARCON 773 BEARING BRONZE (SAE 660)—260 sizes of rods and tubes. Complete range of sizes from ½" to 9" diameters, up to 105" lengths.

ASARCO

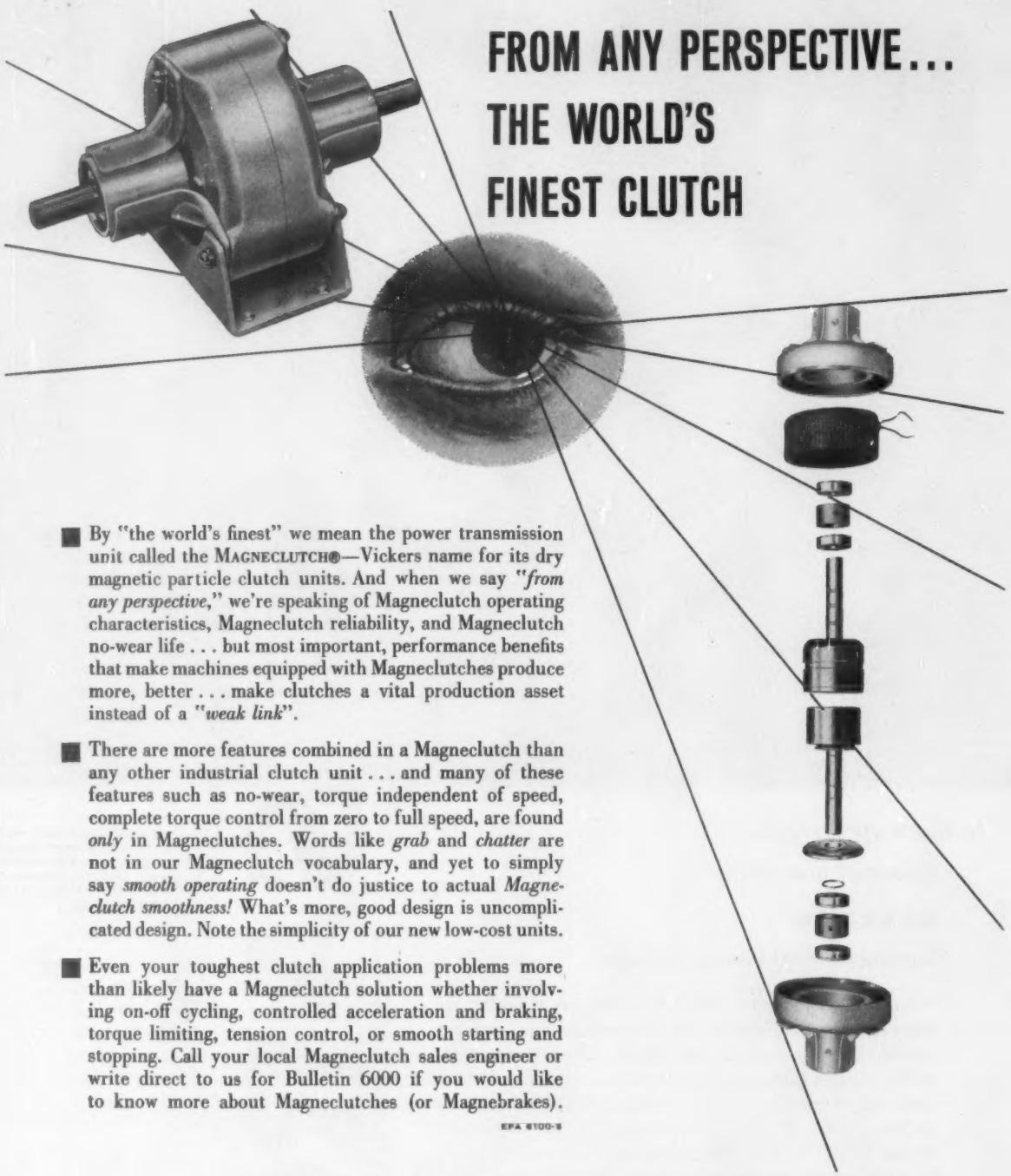
AMERICAN SMELTING AND REFINING COMPANY

CONTINUOUS CAST DEPARTMENT

Bronze part illustrated was machined from a hexagon shaped continuous-cast tube. This custom-cast shape was produced precisely to the customer's alloy, shape and dimension specifications.

West Coast Distributor: Kingwell Bros., Ltd., 457 Minna Street, San Francisco, Calif. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal. Distributors in many principal cities.

Circle 512 on Page 19



FROM ANY PERSPECTIVE... THE WORLD'S FINEST CLUTCH

■ By "the world's finest" we mean the power transmission unit called the MAGNECLUTCH®—Vickers name for its dry magnetic particle clutch units. And when we say "*from any perspective*," we're speaking of Magneclutch operating characteristics, Magneclutch reliability, and Magneclutch no-wear life . . . but most important, performance benefits that make machines equipped with Magneclutches produce more, better . . . make clutches a vital production asset instead of a "*weak link*".

■ There are more features combined in a Magneclutch than any other industrial clutch unit . . . and many of these features such as no-wear, torque independent of speed, complete torque control from zero to full speed, are found *only* in Magneclutches. Words like *grab* and *chatter* are not in our Magneclutch vocabulary, and yet to simply say *smooth operating* doesn't do justice to actual *Magneclutch smoothness!* What's more, good design is uncomplicated design. Note the simplicity of our new low-cost units.

■ Even your toughest clutch application problems more than likely have a Magneclutch solution whether involving on-off cycling, controlled acceleration and braking, torque limiting, tension control, or smooth starting and stopping. Call your local Magneclutch sales engineer or write direct to us for Bulletin 6000 if you would like to know more about Magneclutches (or Magnebrakes).

EPA 6100-S

VICKERS INCORPORATED
Division of SPERRY-RAND Corporation

ELECTRIC PRODUCTS DIVISION

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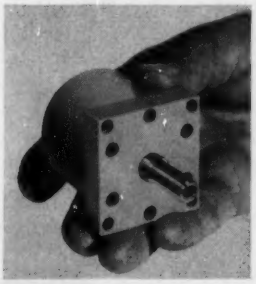
SALES ENGINEERING OFFICES:

BOSTON (Rep.), *CEdar 5-6815* • **CHICAGO**, *JUniper 8-2125* • **CHICAGO (Distr.)**, *FRanklin 2-7272* • **CLEVELAND**, *EDison 3-1355* • **DALLAS (Rep.)**, *EMerson 8-4655* • **DENVER (Rep.)**, *MAin 3-7201* • **DETROIT**, *TOwnsend 8-5100* • **DETROIT (Distr.)**, *TRinity 4-1010* • **GREENVILLE (Rep.)**, *CEdar 2-2421* • **LOS ANGELES**, *DAvenport 6-8550* • **LOS ANGELES (Distr.)**, *MUtual 3144* • **MILWAUKEE (Distr.)**, *ORchard 2-9220* • **NEW YORK CITY**, *LEnox 9-1515* • **PITTSBURGH (Rep.)**, *ATlantic 1-4692* • **SAN FRANCISCO (Rep.)**, *JUniper 6-1860* • **WASHINGTON, D. C.**, *EXecutive 3-2650*



construction machines, remote control of valves, and other light applications. **Greenville Plant, Ex-Cell-O Corp.**, 945 E. Sater St., Greenville, Ohio.

Circle 652 on Page 19

Flow Regulator

has adjustable regulated flow of 0 to 0.5 gpm

Externally adjustable, cartridge-type, low-capacity flow regulator maintains constant regulated flow regardless of variations in pressure. Used in hydraulic circuits requiring low flow, valve has an adjustable regulated flow of 0 to 0.5 gpm and an adjustable total flow-control rate of 5 per cent within 600 to 2000-psi operating - pressure range. In addition, it has a low pressure drop of 50 psi at 0.13 gpm. Weighing only 9 oz, valve is stain-

less steel and anodized aluminum, and handles all fluids compatible with these materials. **Fluid Regulators Corp.**, 313 Gillette St., Painesville, Ohio.

Circle 653 on Page 19

Commercial Rivets

are adaptable to various material thicknesses

New commercial rivets speed production and reduce costs in either blind or open applications. Rivets have minimum blind-side clearance,

- Large Manufactured Head
- Oversize Blind Head
- Plugged or Hollow
- No Stem Trimming
- Minimum Blind-Side Clearance
- Excellent Head Seating
- Wide Grip Range
- Full Range of Diameters
- Positive Hole Fill
- Easy Installation

For fast, secure, more economical fastening, the new Cherry Commercial Rivet is a blind fastener ideal for production manufacturing and repair. Installed by one man from one side of the work, the Cherry Commercial Rivet reduces cost of assembly, repair and maintenance in both blind and open applications.

Minimum blind side clearance, adaptability to variations in material thickness, and positive hole fill even in oversize or out-of-round holes offer advantages not available in other production fasteners.

Cherry Commercial Rivets are available in both hollow (non-structural) and plugged (structural) types. The plugged rivets have strength values comparable to solid rivets, and stems fracture to eliminate all trimming operations and provide further production economy.

Grip lengths from 1/16" to 1" inclusive, and diameters of 1/8", 5/32", 3/16" and 1/4" are provided in either universal or countersunk head. Special rivets are manufactured to order.

For full technical information on the new Cherry Commercial Rivet, write Cherry Rivet Division, Townsend Company, Box 2157-E, Santa Ana, California.

Aluminum Mild Steel Monel

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

ESTABLISHED 1816 • BEAVER FALLS, PA.

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

Circle 514 on Page 19

FAWICK designer's pool of power transmission products

VC Centerline Clutch and Brake — Bulletin ML-102-A
CB Clutch and Brake — Bulletins ML-176-A, ML-172, 500-A2
FSPA (Fawick Standardized Press Application) Bulletin ML-172, 500-A2
Standardized CB Clutch Package Applications — Bulletins ML-176-A, 500-A2
Liqui-Cool Clutch and Brake — Bulletin ML-18
Magnetic Clutch and Brake — Bulletin M-105S

FAWICK can provide you with components for the best performance in power transmission.

FAWICK plants produce a complete line of clutches, brakes and controls—air-actuated constricting and expanding types, and magnetic types—ranging in size from 2½ to 84-inch diameters, with torque ratings from 27 to 3,000,000 inch-pounds.

There is a size and type that will suit your application and operating requirements exactly.

For additional information, call in your nearest FAWICK representative or write for Bulletins listed with the products shown.

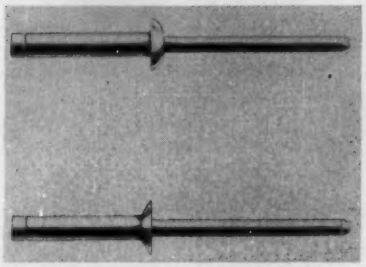
FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX

INDUSTRIAL CLUTCHES AND BRAKES

Circle 515 on Page 19

adaptability to different material thicknesses, and positive hole-fill even in oversize or out-of-round holes. Available in plugged (structural) and hollow (nonstructural) types, rivets are applied from one side of the work. Rivet stems fracture cleanly and quickly, and trimming operations are eliminated. Rivets are available with universal or countersunk heads in grip lengths



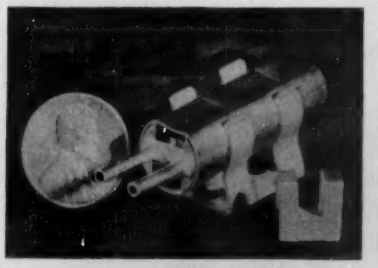
from 1/32 to 1 in. Diameters are 1/8, 5/32, 3/16, and 1/4 in. **Cherry Rivet Div., Townsend Co.,** Box 2157-Z, Santa Ana, Calif.

Circle 654 on Page 19

Miniature Air Switch

is magnet-actuated unit

Pneumation Model 1035 miniature air switch is a magnet-actuated device only 1½ in. long and ½ in. in diam, weighing less than 2 oz. Designed especially for use in pneumatic circuits where only a very low actuating force is available, switch has no mechanical linkage or striking parts. It can be used in place of electrical components such as electric limit switches, electric pressure switches, solenoid valves, and other electrical devices in ordinary service, as well as in areas where there is an explosion hazard. Features include snap action when energized or de-energized by a small magnet on a moving member of a mechanism, low air consumption, and maximum pressure of 25



YOU CAN PUT YOUR FINGER ON THE REASON

Why "MARK-TIME" MECHANICAL TIMERS should be INVESTIGATED!

Low cost mechanical Timers, Time Switches and Time Devices **can** be quite sophisticated. For example: they can be designed to ring bells, flash lights, turn valves, cut cords, start, stop or operate electrical or mechanical equipment, and to do all this **after** a pre-selected time period has elapsed.

The "Mark-Time" mechanical "memory" **cannot** fail due to an electrical failure since it is spring powered.

The "HEART" of the "Mark-Time" is of a new super-tough alloy which prolongs mainspring life indefinitely.

This new special steel virtually **eliminates** mainspring failure. This adds extra sales features to your product at no extra cost.

The "MARK-TIME" Mainspring is Unbreakable!

Tensile strength, durability and corrosive resistance is unexcelled. No other Timer on the market has these exclusive features.

At present, we manufacture more than 3,000 DIFFERENT kinds of custom-built timers for industrial, consumer and military applications. Thus, we are the **largest** manufacturer of mechanical timers in the **world**!

Research and development work welcome—small runs our specialty.

Sales engineers in 27 key cities at **your** service.

Write for your copy of this **new** Engineering Handbook on Timers, specifically written and illustrated for the Design and Development Engineer.

MARK-TIME

M. H. RHODES, inc.

HARTFORD 6, CONNECTICUT

Circle 516 on Page 19

put HEINZE in your designs

2 13/32" of POWER

HEINZE UNIVERSAL MOTORS

Type AD, smallest of Heinze Universal Motors, is only 2 1/32" in diameter, 3¾" long (excluding shaft), and weighs 1½ lbs. Where size is critical but a universal motor is required, Type AD is ideal for intermittent duty applications such as vending machines, automotive or low voltage requirements. At 5,000 rpm load speed, motors develop the following horsepower ratings: 6V, DC — 1/30; 6V, AC — 1/40; 12V, DC — 1/30; 12V, AC — 1/40; 115V, AC/DC — 1/40. Slightly higher hp ratings are available for highly intermittent operations. CW or CCW rotation. Die cast or drawn steel case. Wide choice of modifications.

Send coupon for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence Street
Lowell, Massachusetts
SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

HEINZE ELECTRIC COMPANY
685 Lawrence Street, Dept. D
Lowell, Massachusetts

Please send catalog on Heinze Sub-Fractional Horsepower Motors and Blowers.

Name and Title.....

Company.....

Street and No.....

City and State.....

Circle 517 on Page 19

psig. Bleed rate is 0.05 scfm at 10 psig when de-energized, and zero when energized. **Associated Control Equipment Inc.**, P. O. Box 136, Coraopolis, Pa.

Circle 655 on Page 19

Synchronous Motor

is low-cost unit

Synchronous motor combines the features of hysteresis motors with lower cost of shaded-pole motors. Permanent magnetization of both ends of an induction motor gives rotor a combination of synchronous and induction torque. Motor permanently locks into synchronous speed and is free from slip. Applications for the motor include phonograph drives, tape recorders, transcription turntables, timer applications, data processing, and equipment associated with recording charts and graphs. Unit is shown compared in size with a standard 45-rpm phonograph record. **Alliance Mfg. Co. Div., Consolidated Electronics Industries Corp.**, Alliance, Ohio.

Circle 656 on Page 19

High-Strength Bolts

for use at 1200 F

EWB 1218 bolts, for use at temperatures to 1200 F, have 39 per cent greater tensile strength and 54 per cent higher stress-rupture strength than current elevated-temperature bolting used in the 900-1200 F range. Development indicates weight savings in missiles and airframes, jet and rocket engines, and power equipment. Bolts are intended for applications where standard 1200-F bolting of A-286 alloy is currently used. Bolts, made of U-212 alloy, have minimum ultimate tensile

CASH-ACME . . . meeting pressure control needs for product design engineers everywhere

Type Vacuum Regulator Valve D-51

CASH-ACME VACUUM REGULATOR VALVE PREVENTS CIGARETTE JAM IN NEW FILTER TIPPING DEVICE

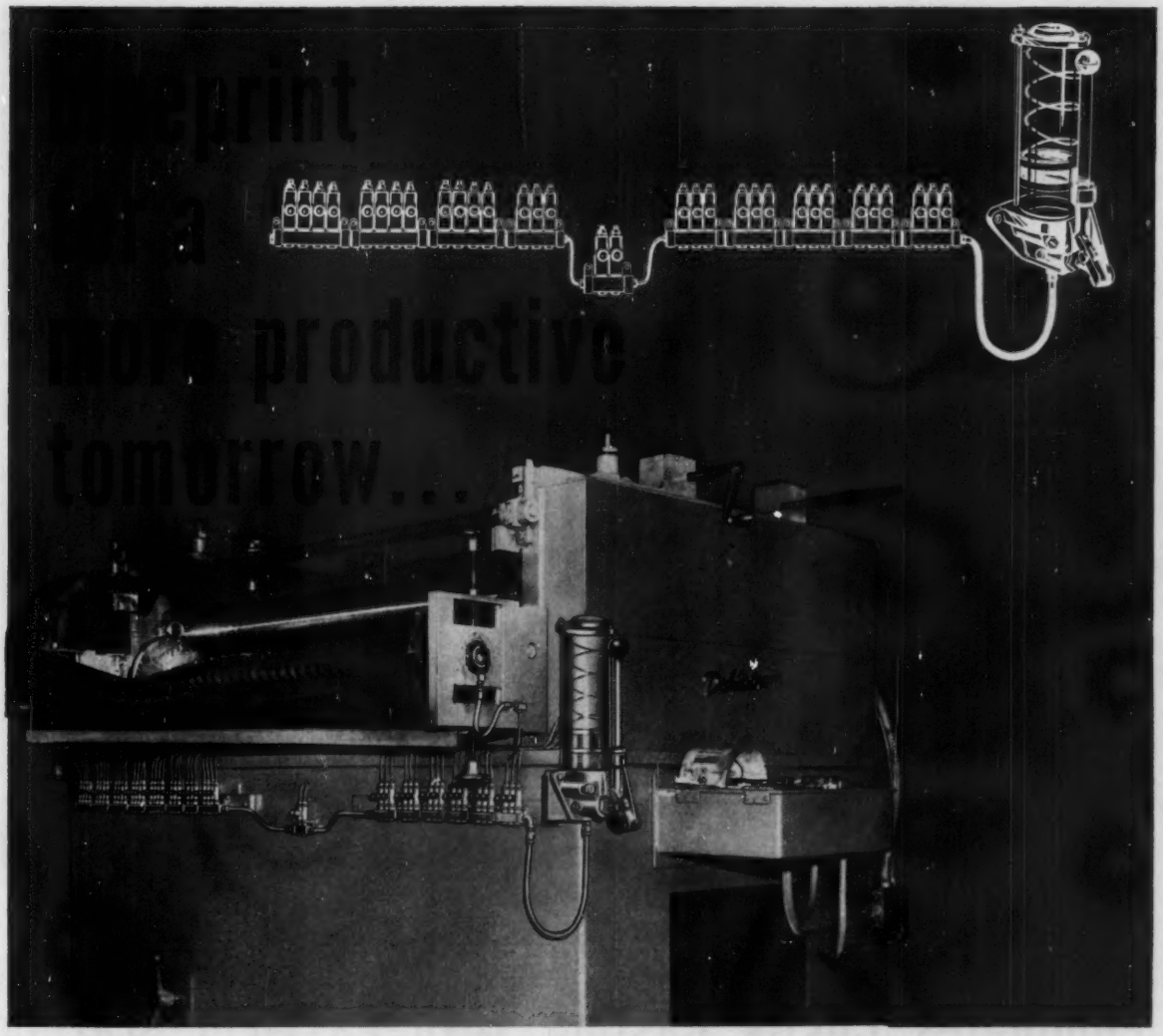
To keep pace with fantastic demands for filter tipped cigarettes (now 40% of the market), manufacturers are attaching a new kind of tipping device to machines —capable of tipping 780,000 cigarettes in a 10-hour run

Designers give a lot of credit for the device's amazingly foolproof performance to Cash-Acme engineers. An extremely exact "low whisper" vacuum must be maintained at all times... just enough to hold the cigarette while the filter is affixed. This is assured by strategic placing of Cash-Acme Regulator Valve D-51 on the machine's vacuum line which brings high vacuum from the plant's central system. By regulating and keeping the vacuum at the proper level, all chances of "jamming" and production loss are eliminated.

TYPE D-51 VACUUM REGULATING VALVE
Ready for exacting vacuum regulating jobs on any type of equipment. Type D-51 is expressly designed for use in systems where it is desired to maintain, automatically, a lower vacuum at the valve inlet than prevails at the source on the valve outlet. No step-action, no snap-action, but full-floating and automatic.

A. W. CASH VALVE MFG. CORP.
6627 East Wahash Ave., Decatur, Ill.

Circle 518 on Page 19



A *Lincoln* Centralized Lubrication System

In seconds a Lincoln Centralized Lubrication System lubricates all bearing surfaces while machinery is operating. It assures that every bearing gets the right amount of lubricant at the right time, whether you use the simpliest, manually-operated CentrOluber* or a completely automatic CentrOmatic* System. Centralized lubrication cuts downtime and bearing replacement, boosts plant efficiency and production.

Lincoln systems can be actuated by hand, reciprocating motion, air or electricity. There are 26 systems available to meet every lubricant application requirement . . . including *yours*. Mail the coupon today for complete details and specifications.

*Registered Tradename.

Coast-to-Coast Sales and Service through 16 Branch Offices and Leading Industrial Distributors.

1046

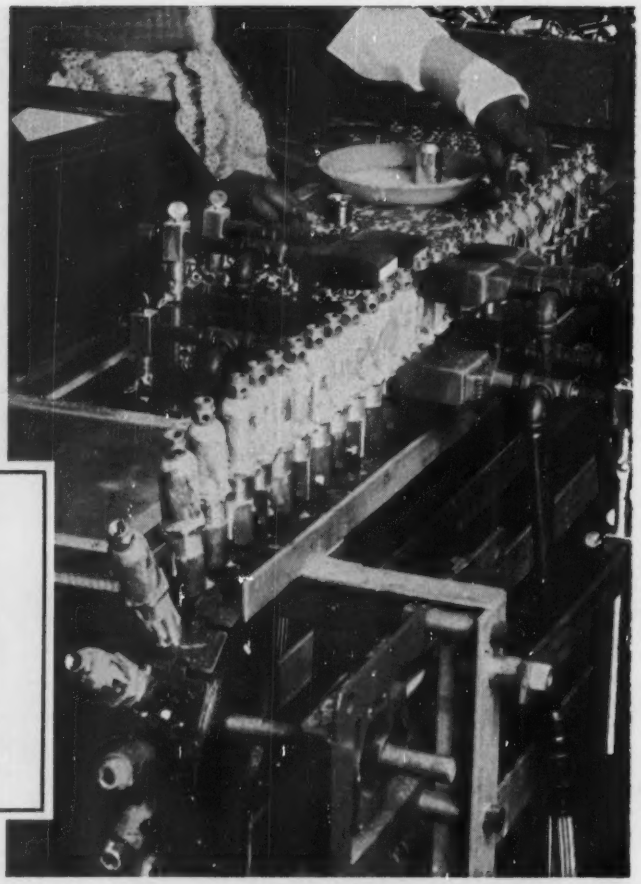
Lincoln

LINCOLN ENGINEERING CO
Division of The McNeil Machine & Engineering Co.
St. Louis 20, Missouri

LINCOLN ENGINEERING CO.
5736 Natural Bridge Ave., St. Louis 20, Mo.

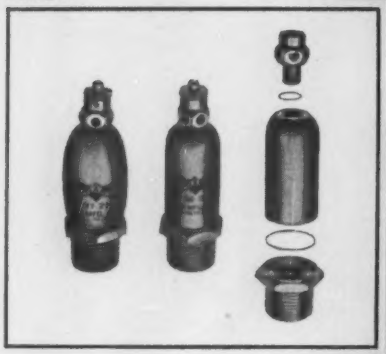
Please send my complimentary copy of Catalog 81 on Lincoln Centralized Lubrication Systems.

Name.....Title.....
Company.....
Address.....
City.....Zone.....State.....



Operator dips parts in HANDY FLUX and assembles them with EASY-FLO 45 rings on a moving rig. Assemblies then pass between banks of gas burners to complete brazing process. Capillary action of EASY-FLO brazing alloy insures thorough penetration—guarantees high strength, leakproof joints.

Flair No. 21 Hot Water Air Vent consists of the basic free-venting air valve, a generous air-collection chamber and a massive hex base. Two preform rings of EASY-FLO 45 are used in the brazing operation. Valve assembly at left was subjected to extreme pressure. Note how body ballooned; joints strong and leaktight.



How Flair Manufacturing Speeds Production, Eliminates Costly Casting With Easy-Flo Brazing

Never a field failure in any joint brazed with EASY-FLO 45 and HANDY FLUX—that's the proud record of Flair Manufacturing Company, Brooklyn, New York, makers of an extensive line of air valves and other specialties for steam and hot-water systems.

Flair finds that brazing with EASY-FLO 45 offers competitive advantages in every aspect of design, production economy and service life. Big savings are made through elimination of costly casting equipment and more productive use of space. Production is smoother, faster. Valves look better, last longer... in tests to 5000 psi, valve bodies burst while brazed joints remain intact. All this for an alloy cost per unit of approximately 2½¢ for two preform rings of EASY-FLO 45.

Speed, strength, economy, low labor costs—advantages *any* manufacturer would be glad to have. And, all achieved through use of Handy & Harman silver alloy brazing. Chances are silver alloy brazing could benefit your product too. If it could, or if you think it *might*, don't hesitate to get in touch with Handy & Harman. We'll help you in every way possible. Why not call us today?

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strengths of 180,000 psi at room temperature and 130,000 psi at 1200 F. Fasteners are 12-point external-wrenching bolts of standard configuration. They are furnished in diameter sizes No. 10 through ½ in. with fine threads. **Standard Pressed Steel Co., Jenkintown, Pa.**

Circle 657 on Page 19

Silicone Glass Laminate

has very high impact strength

Low-cost silicone glass laminate with excellent electrical properties, high impact strength, and low moisture absorption is now available. Designated Lamicoid No. 4053-3, it is suitable for a wide variety of Class-H equipment. Made with a continuous-filament, coarse-weave glass cloth, heat-resistant laminate withstands continuous exposure to 200 C. Material meets the requirements of NEMA G-7 laminates and also is qualified under military specification MIL-P-997B. It is available in thicknesses of 1/32 to ⅜ in. in sheet size 36 x 42 in., and ⅜ to 2 in. in 18 x 36-in. sheet size. **Mica Insulator Div., Minnesota Mining & Mfg. Co., Schenectady 1, N. Y.**

Circle 658 on Page 19

Flow-Relief Valve

has self-cleaning orifice

Flow-relief valve for hydraulic systems accurately controls line pressure by instantly responding to surges at any rate of flow. Unit is designed for use as a straight relief, sequence, or bypass valve. Pin-and-hole orifice at inlet pressure port is self-cleaning, with pin moving in the hole with changing pressures, eliminating clogging. Pilot valve actuating pin is exposed to

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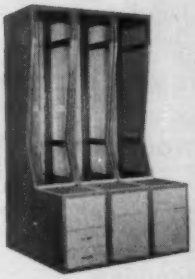
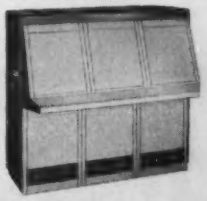
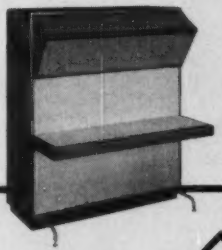
Provides Cooling, Mounting and Lighting in Modular Enclosures for Electronic Instruments in Any Installation



Aluminum



Semi-Custom



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No one type of enclosure meets all environmental and physical demands. AMCO has developed 3 complete systems integrated into 1 system with interchangeable accessories, applicable for both commercial and military use.

CUSTOM... When space and appearance are critical ...16 ga. double-channel steel frames, based on increments of 19⅛" widths, supports in excess of 3000 lbs. Multi-width panels and cowlings give single-unit appearance with series mounted racks. Meets EIA Standards.

SEMI-CUSTOM... Heavy-duty, more internal clearance... 14 ga. box-channel steel frames, 12 ga. gusseting provides exceptional rigidity both front-to-back and side-to-side. Frames based on 22⅛" increments provides clearance for recessing 19" wide panels. Meets EIA Standards.

ALUMINUM... Unique! Meets any size... almost any configuration from 6 basic parts... 3 castings and 3 extrusions. Any size from 6" to 20 ft.; any slope from 0° to 90° is standard. Mil Specs strength and material (6061-T6 extrusions and 356-T6 castings).

Amco manufactures all necessary blowers, chassis slides, doors and drawers, writing surfaces, cowling lights and other accessories. **Check the extra savings you get thru Amco's combined-discount system of racks and accessories.** *PLUS FREE ASSEMBLY.*

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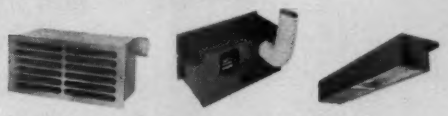

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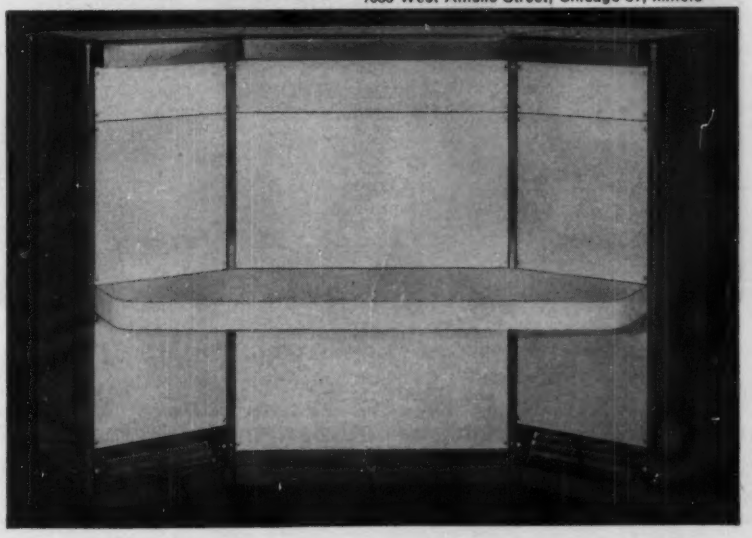

Circle 521 on Page 19

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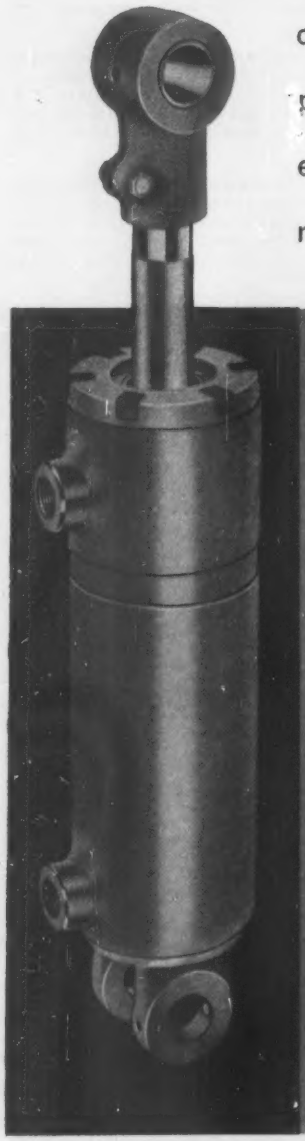
of BHEW in a wide variety of applications is your assurance of dependable product performance. BHEW's engineering experience in precision manufacturing insures lasting service.



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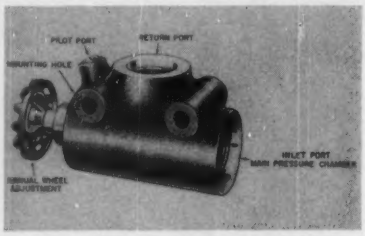


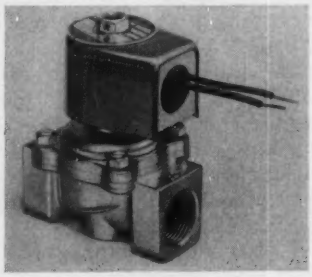
line pressure at all times, providing instant response to pressure surges. Pressure regulation is constant from cracking to full open, with a differential of less than 100 psi from trickle to full flow and less than 50 psi between cracking and closing. Valve is available in 30 and 80-gpm capacities, with straight or pipe-threaded ports. **Hydraulic-Electronic Div., Fawick Corp.**, 9919 Clinton Rd., Cleveland 11, Ohio.

Circle 659 on Page 19

Solenoid Valve

for low-pressure control systems

Compact solenoid valve with ¾-in. pipe connections has a forged-brass body and bonnet, and soft composition disc. It can be used in any low-pressure control system. Various features consisting of explosion-proof or watertight solenoid enclosures, manual operators, and



mounting brackets can be supplied. **Automatic Switch Co.**, Florham Park, N. J.

Circle 660 on Page 19

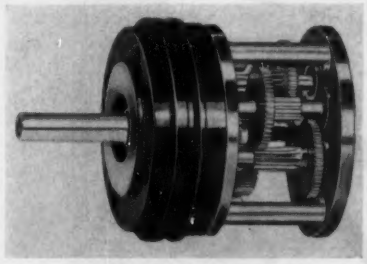
Gear Heads, Speed Reducers

for temperatures from −55 to + 150 C

Standard gear heads and speed reducers are available in a wide variety of ratios, in sizes 8, 10, 11, 15, and 18, with internal, preset, mechanical slip clutches. Clutches op-

Circle 522 on Page 19

erate in either direction throughout temperature range of −55 to +150 C, with a maximum torque variation of 7 per cent. Maximum torque variation at constant temperature is less than 2 per cent. All clutches slip for 150 hr continuous duty. Torque can be set from 3 to 200 oz-in., depending upon size of gear head. All units conform to applicable military specifications and have maximum backlash at the output shaft of 30 min. Class



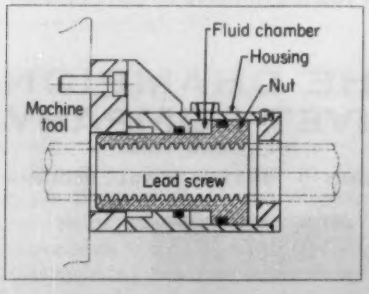
ABEC 7 ball bearings are used throughout. **Kinetic Instrument Corp.**, 1070 Linwood St., Brooklyn 8, N. Y.

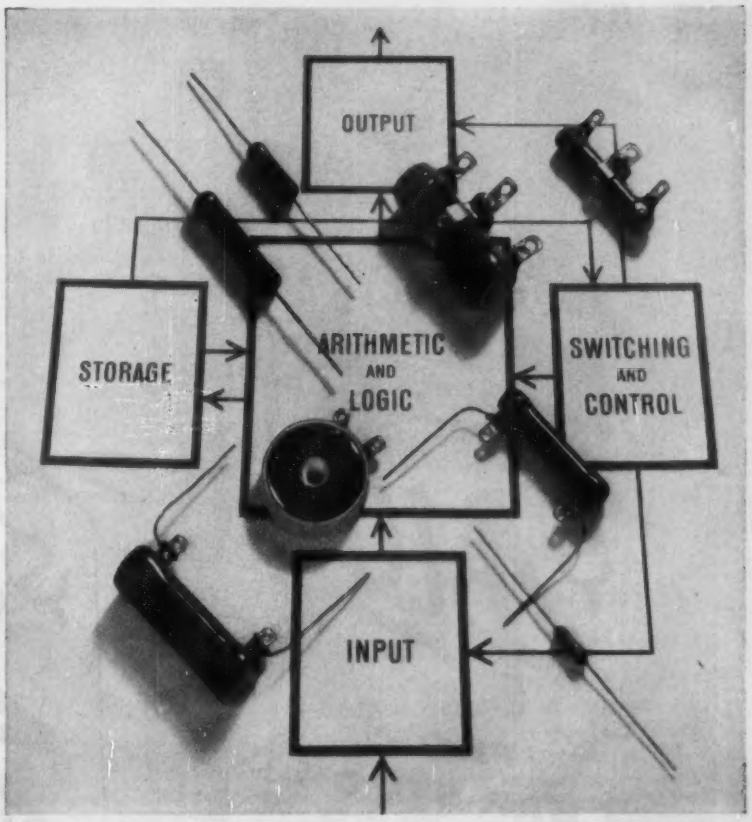
Circle 661 on Page 19

Hydraulic Nut

automatically maintains lead-screw accuracy

Hydraulic take-up screw nut is designed for use in screw-driven machines and mechanisms. Nut eliminates backlash, even after excessive wear of threads, eliminating vibrations, chatter, and bad surface finish of the work. Nut also provides a continuous breaking force which prevents undersired rotary motion and securely locks elements in position as long as power is not applied. Basically, assembly is a pair of bronze nuts which have threads engaged with lead screw. One nut is locked, the other is forced in the opposite axial direc-





In modern digital computers

PERFORMANCE IS THE PAY-OFF

A big, modern digital computer may cost as much as $10-million to buy outright. Even rental may run as high as $50,000 a month.

With money like that involved, computer-makers can't take a chance on substandard components. They want, and get, the best components .... the best resistors. Where wire-wound power resistors are required, they frequently specify Ward Leonard VITROHMS.

There's another reason, too, why computer manufacturers want only the best: They're shooting for 99.99...% statistical reliability of *components*, and the more "9's" the better. Computer components – say, resistors – are numbered in the tens of thousands, and they have to have this kind of performance to get 99.8% reliability in their final product. For this reason, computer makers insist on, and get, *performance*–as continuous and reliable as the state of the art permits. And again, where wire-wounds are required, they are likely to specify Ward Leonard VITROHMS.

If you want maximum quality and maximum reliability in your product, follow the lead of outstanding digital computer manufacturers–like IBM, Remington Rand, and Burroughs–and specify W/L VITROHMS. You'll find full information in catalog D130. Write for your copy, and the name of your nearest VITROHM distributor, today. Ward Leonard Electric Co., 58 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.) o.e

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Circle 523 on Page 19

Champion Upset Forgings Cut Valve Manufacturer's Finished Cost 30%!

At first glance this valve part looks like a typical screw machine product. But see that big wad of metal on the end of the stem? . . . It's the tip-off that you can save money with an upset forging.

Any automatic screw machine part must start with stock of the largest part diameter and be worked down . . . with considerable waste.

In upset forging, you generally start with the smallest diameter and increase the part size to the largest diameter . . . with almost no waste. Forging also increases strength, by directioning grain flow in the metal.

If you're using similar parts, check with Champion and see how much you too can save by starting with an upset forging.

THE CHAMPION RIVET COMPANY
T. P. Champion, President
CLEVELAND 5, OHIO • EAST CHICAGO, INDIANA

When it's a vital part, better make it FORGED

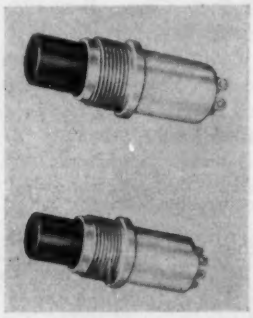
tion by hydraulic fluid pressure, thus exerting wedging or preloading action upon the lead screw. **Tracer Control Co.**, 595 E. Ten Mile Rd., Hazel Park, Mich.

Circle 662 on Page 19

Pushbutton Switches

are moistureproof units

Two moistureproof pushbutton switches are designed for applications in both ground support and aircraft equipment. The J3136 is a moistureproof, push-push, two-circuit switch rated at 5 amp inductive or 10 amp resistive, 28 v dc; 5 amp inductive, or 10 amp resistive, 120



v ac. Measuring 1 19/32 in. long, unit features an anodized-aluminum case, solder-dipped terminals, and a minimum life of 25,000 operations at rated load. Eight mounting adapters and four plunger-cap colors are available. The J3336 is a double-pole, double-throw switch similar in design. It is rated at 1 amp 28 v dc resistive or 1 amp 120 v ac resistive. Both switches have an operating pressure of 2¾ lb and have a total plunger travel of 11/64 in. **Control Switch Div., Controls Co. of America**, 1420 Delmar Drive, Folcroft, Pa.

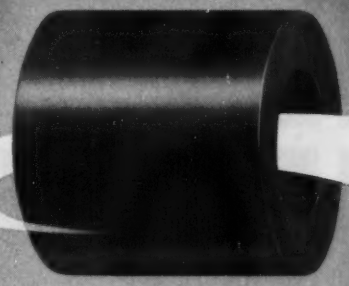
Circle 663 on Page 19

Motor Mounts

all-steel units are predrilled

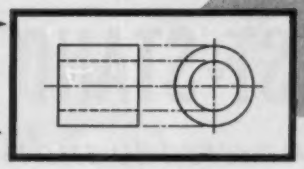
All-Steel Equi-Poised motor mounts are available for mounting motors directly to the steel frame of Falk shaft - mounted, flange - mounted, and screw-conveyor drives in the ½ to 30-hp range. Rigid, all-steel weldments are predrilled to accommodate all related NEMA foot-mounted motors within the

HYDRO-AIRE specifies MORGANITE



—for extra reliability in *hytrol* anti-skid braking systems!

Hytrol Anti-Skid Braking Systems, a development of Hydro-Aire Company, are widely used on fighters, bombers, commercial transports and surface vehicles. Self-lubricating Morganite components are employed in these systems because of their smooth-functioning, reliable performance. Another example of Morganite's ability to meet today's critical requirements.



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Circle 525 on Page 19

Special reversible high-speed reduction unit, 8,000 HP, 18,000/1,295.5 RPM.

Special speed-increasing unit, 660 HP, input speed range: 1,500 to 3,000 RPM, output speed range: 20,000 to 40,000 RPM.

Special right-angle speed-increasing unit, 600 HP, 2,500/19,932 RPM; with double helical and spiral bevel gears.

Special 375 HP speed-increasing unit, with two speed ranges: 6,000/10,769 RPM and 6,000/15,100 RPM.

TEST-STAND GEAR UNITS

engineered to individual requirements

Here are four examples of Farrel high-speed gear units designed for test-stand service. Each embodies the solutions to a whole series of problems — presented by the customers' individual requirements, and by the high peripheral speeds involved. Each is a challenge in itself.

That such units can be designed for successful operation is due to (1) Farrel's long experience in meeting "extraordinary" specifications for gear units, and (2) the inherent accuracy of the Farrel method of gear generation.

Put this experience to work the next time you need a test-stand gear unit. In the meantime, send for bulletin 451.

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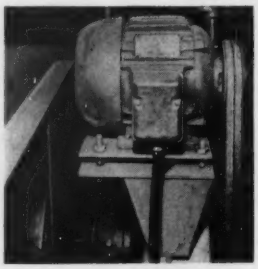
FB-1196



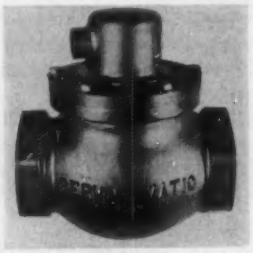
rated capacity of the reducers. Used with shaft-mounted drives, balanced design results in zero reaction from belt pull at headshaft bearings, thus reducing bearing loads on the driven machine. Adjusting screws provide a quick, convenient method of tensioning V-belts. **Falk Corp.**, Box 492, Milwaukee 1, Wis.

Circle 664 on Page 19

Solenoid Valve

for control of noncorrosive liquids

Designed for low-cost control of air, gas, light oil, and other noncorrosive liquids, solenoid valve operates within pressure ranges of 2 to 400 psi. It is now available in ½ to 4-in. line sizes. Design of the unit offers contamination-free operation and built-in protection against jamming and wear through the use of internal screens, strainers,



and wear rings. Valve can be serviced without removal from the line. Solenoids are available in dc to 30 v and ac to 200 v. **Servo-Matics**, Box VC 9455, North Hollywood, Calif.

Circle 665 on Page 19

Synchro Clamp

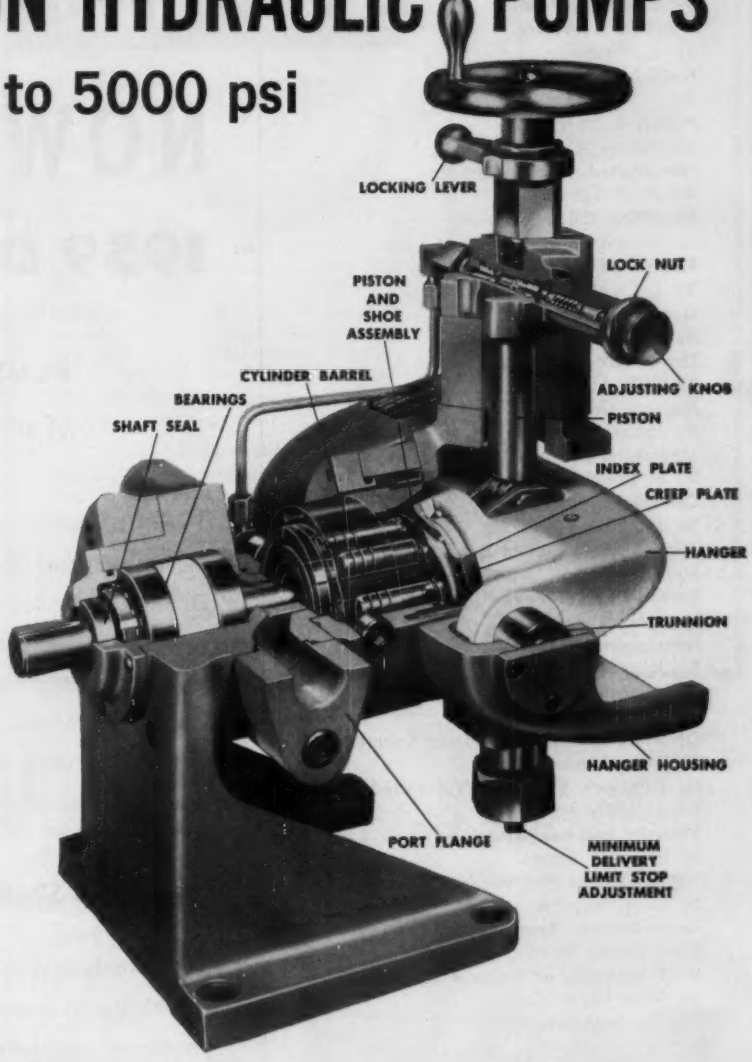
securely fastens miniature components

Quick-release, self-locking Mini-Synclamp permits easy, secure fastening

Circle 526 on Page 19

Design of variable volume
AXIAL PISTON HYDRAULIC PUMPS
for systems up to 5000 psi

By: Ellis H. Born
Director of Sales-Engineering
Denison Engineering Division
American Brake Shoe Co.



For 5000 psi requirements, the axial piston pump (illustrated) is a logical choice. It operates on the principle of a series of pistons in a common barrel that progressively draw oil into the barrel on the suction stroke and force oil from the barrel into the line on the discharge stroke.

With this simple axial piston design, direct and unrestricted flow into the pumping assembly is possible, eliminating the need for the large flow areas used and the moving seals which, in turn, eliminates maintenance. Direct flow path further insures good suction characteristics —a highly desirable operating advantage for obtaining efficient hydraulic performance.

The port plate of the Denison pump is designed as an axial hydrostatic bearing which balances out the thrust of the cylinder barrel, leaving only sufficient force to create a positive seal contact between the cylinder port plate and the cylinder barrel. Because of reduced thrust, wear on mating surfaces is decreased and pump life is greatly extended at all pressures up to 5000 psi.

Where variable volume is required, it is logically desirable (for efficiency, simplicity and low maintenance) to eliminate the need for varying the position or angle of the cylinder barrel to regulate volume. In the Denison axial piston pump, output is simply regulated by varying cam plate angle. Zero to full flow or flow reversal is regulated by handwheel, hydraulic cylinder, stem, electric motor, compensator or electrohydraulically.

In the Denison design, the line of action of the combined radial load of all pistons is through the roller bearing supporting the cylinder barrel. The use of a large bearing provides non-deflecting support for these radial forces. As a result, unbalanced or twisting offset that would tend to unseat the cylinder barrel from the port plate is eliminated. A continuous, effective sealing action of the barrel against the port plate is maintained to promote high pumping efficiency.

Piston and shoe assembly design also reduces by one-half the number of ball and socket couplings found in other types of axial piston pump construction. The shoes hydraulically balance out all piston thrust, eliminating need for thrust bearings.

Data and specifications on 5000 psi pumps, motors and controls are available from your Denison representative—located in principal cities—to assist you in developing hydraulic systems for maximum efficiency and economy.

NEW CATALOG FOR DESIGNERS AND ENGINEERS

Write for your copy of Bulletin 220—"Hydraulic power to 5000 psi". Includes complete specifications, operating data and applications for Denison's full line of hydraulic pumps, motors and controls.

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

Circle 527 on Page 19

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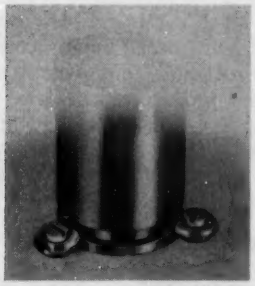


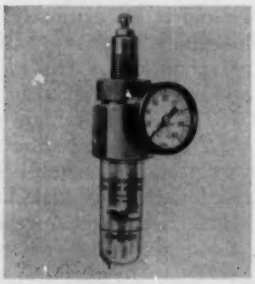
of Size 5 through Size 11 miniature components to any base. Quick release is attained by the use of a nylon insert of Zytel 103, making clamp and screw an integral unit. When screw in clamp is tightened, insert is squeezed, allowing screw to self-align perfectly. Once aligned, unit locks and unlocks by turning screw against integral stop. Lamps meet and exceed specifications of MIL-E-5272 and are functional to temperatures of 350 F. Units are available from stock in four grip thicknesses of 0.031, 0.047, 0.062, and 0.093 in. **Timber-Top Inc.**, 38 Brooklyn Ave., Freeport 2, L. I., N. Y.

Circle 666 on Page 19

Small Pneumatic Products

provide high degree of performance

Line of compact pneumatic products consists of small, high-performance manual and automatic-drain compressed-air filters, pressure regulators, diaphragm-type relief valves, and Micro-Fog lubricators. Units are designed for applications that require a high degree of performance, where standard equipment is too large. Any combination of the units is available. Regulators and relief valves are used with air, water, oil, and similar fluids. All units are made for ⅛-in. pipe size, and regulators



FLUID & AIR CONTROL VALVES
DESIGNED FOR VOLUME USERS

★ LOW-COST
★ DEPENDABLE
★ VERSATILE
★ TROUBLE-FREE

SPECS IN BRIEF...

SIZES: ⅛" to ¾" NPT.

PRESSURE RANGES: Up to 2000 PSI for brass and aluminum. Up to 5000 PSI for steel or stainless.

MATERIALS: Stocked in brass and steel. Available in stainless, aluminum, and other alloys to order.

FEATURES: Low initial cost and less maintenance. High flow-to-size ratios. "Straight-thru" principle cuts friction loss and clogging. Easy to install.

USED BY the biggest names in American industry . . . and in military applications.

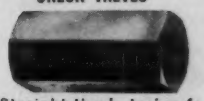
DESIGN MANUAL

Complete specifications and design aids in handy file-size folder is yours on request. Write on letterhead or use inquiry card.

TRUE-FLO® VALVE company, inc.

800 Bow St., Everett 49, Mass.

CHECK VALVES



'Straight-thru' design for highest flow and dependability. Free-moving ball principle.

FLOW CONTROL VALVES

Adjust flow rate (in stepless ranges) with common screwdriver before, during, or after easy installation.

DUAL CONTROL VALVES

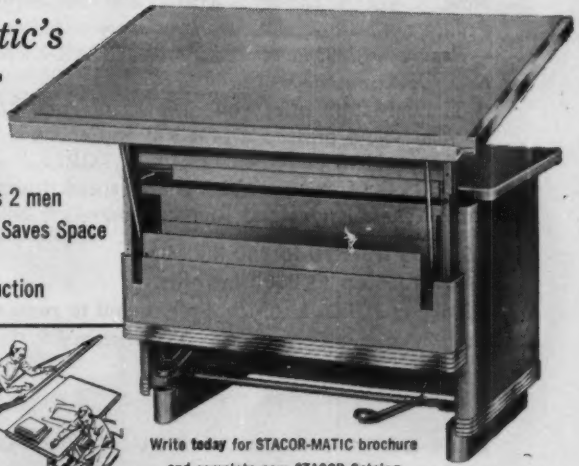
Unique . . . controls flow in both directions independently! True 2-way control for little more than the cost of one flow control valve.

Circle 529 on Page 19

up front STACOR-*MATIC* drawing tables **and in back**

Stacor-Matic's **got it...** *where it counts!*

★ One unit serves 2 men
★ Saves Time ★ Saves Space
★ Cuts Fatigue
★ Increases Production



Complete Drawing Station for one man
Reference Desk and Files for another man

Write **today** for STACOR-MATIC brochure and complete new STACOR Catalog.

STACOR EQUIPMENT COMPANY

Manufacturers of Lifetime Quality Equipment for Schools, Libraries and Industry
273 Emmet Street, Newark 5, N. J. • **Bigelow 2-6600**
Warehouse Stocks in: Boston, Chicago, Detroit, Hartford, Indianapolis, Los Angeles, Montreal, Philadelphia, Rochester, Saint John, N. B., San Francisco, Toronto, Washington, D. C.

Circle 530 on Page 19

NOW! ELIMINATE SPEED REDUCTION COST

Char-Lynn HYDRAULIC ORBIT MOTORS

Deliver HIGH TORQUE at LOW SPEED

Now you can eliminate costly and cumbersome *Speed Reducers — Save* valuable *working space — Increase efficiency — Reduce Maintenance costs* with CHAR-LYNN ORBIT MOTORS.

These Motors offer you a *new concept in fluid power mechanics* and provide a practical and economical solution to the problem of providing HIGH TORQUE — at LOW SPEEDS for Constant and Variable speed drives — Hydrostatic Transmissions and Remote Controls.

- **SPEEDS from 10 to 800 R.P.M.**
- **TORQUES up to 3300 inch lbs.**
- **Starting TORQUE substantially equal to running TORQUE**
- **High Volumetric and over-all efficiency**
- **Compact and low in weight**
- **Standard mountings available**

FOR DETAILS ON THESE HIGH TORQUE... LOW SPEED Motors write to:

Char-Lynn

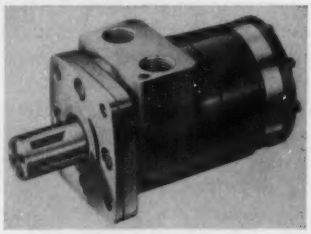
CHAR-LYNN CO.
Hydraulic Horsepower Products
Dept. MD11
2843 26th Avenue South
Minneapolis, Minnesota
PArkway 1-5761

and relief valves are also available for ¼-in. size. Small, combined filter-regulator unit (shown) is a feature product of the line. **C. A. Norgren Co.**, 3400 S. Elati St., Englewood, Colo.

Circle 667 on Page 19

Fluid Motor

is high-torque, low-speed unit



Use of a gerotor mechanism in new fluid motor produces performance characteristics of high torque and low speed. Motor develops up to 3300 lb-in. of torque at 1500 psi with intermittent pressures to 2000 psi. Top speed with smallest power element is 800 rpm; unit develops 500 lb-in. of torque at 1500 psi. Over-all housing length varies from 5.25 to 6.50 in., depending upon thickness of power elements. Diameter is approximately 3.25 in. Motors are instantaneously reversible, and are offered with four types of mountings, three port sizes, and six selections of power element. **Char-Lynn Co.**, Dept. O, 3415 E. 27th St., Minneapolis, Minn.

Circle 668 on Page 19

Air Valves

are rated at 150 psi air

Three and four-way air valves are rated for 1000 cpm continuous duty. Crescent Mach 2 valves have long coil life and improved performance through use of an extremely short solenoid plunger stroke (3/32-in.) and reduction of friction in both pilot and main valve members. Rated at 150 psi air, valves are available in ¼ to ¾-in. pipe sizes. All valves are mounted on sub-base for easy maintenance. **Barksdale Valves**, 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle 669 on Page 19

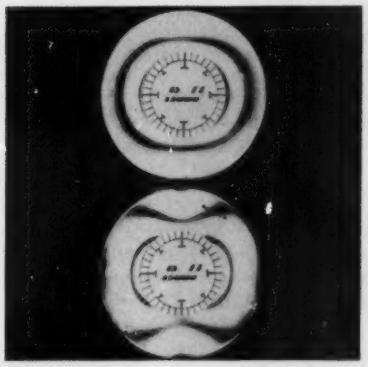
ENGINEERING DEPARTMENT

EQUIPMENT

Rosette Gage

measures orientation and magnitude of strains

PhotoStress rosette gage provides directly both orientation and separate magnitude of principal strains. Measurements of principal strain directions are possible for strain levels as low as 50 mu in. per in. and up. Major and minor principal strain directions are obviously apparent, and separate magnitudes of strains are obtained directly along desired axis. Units provide high readout sensitivity due to permanent pattern. Direct readout is provided, using no instruments or electrical connections. Gage is easily bonded at room temperature to metals, concrete, wood, and other



materials. It will not perform accurately in areas of high strain gradients. **Instruments Div., Budd Co.,** Box 245, Phoenixville, Pa.

Circle 670 on Page 19

Diffusion Transfer Photocopier

makes copies to 12 in. wide by any length

Ampto diffusion transfer photocopier is used primarily to produce permanent photocopies of material to 12 in. wide by any length. Other specialized uses include preparation of positives for offset platemaking, in-

with FULL FLUID STEERING

DESIGN FLEXIBILITY
Allows optional and most convenient positioning of steering wheel. Eliminates cumbersome mechanical linkage to weave around engine and along frame.

OPERATES ANY POWER ACTUATOR
Can be used with simple power steering cylinder—rotary cylinder — or hydraulic motor.

ALLOWS SOUND AXLE DESIGN
All major steering forces can be contained at proper place — the axle. No thrust members needed along frame or at cockpit.

REDUCES STEERING EFFORT AND REMOVES DRIVING SHOCK

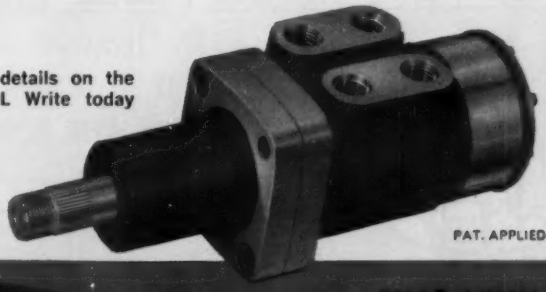
COMPACT SIZE
Wheel mounts on unit — no high forces of gear box to anchor.

ELIMINATES MAINTENANCE PROBLEMS
Minimizes lubrication points—reduces number of highly loaded thrust parts. Removes "worm chipping" — "sector scuffing" — "cam wear" problems.

NO HUNTING
Stable control removes tendency of low frequency hunting in high mass-ratio system.

REVERTS TO MANUAL CONTROL AUTOMATICALLY
In event of engine failure or power loss.

For full details on the ORBITROL Write today to . . .



PAT. APPLIED FOR

Char-Lynn

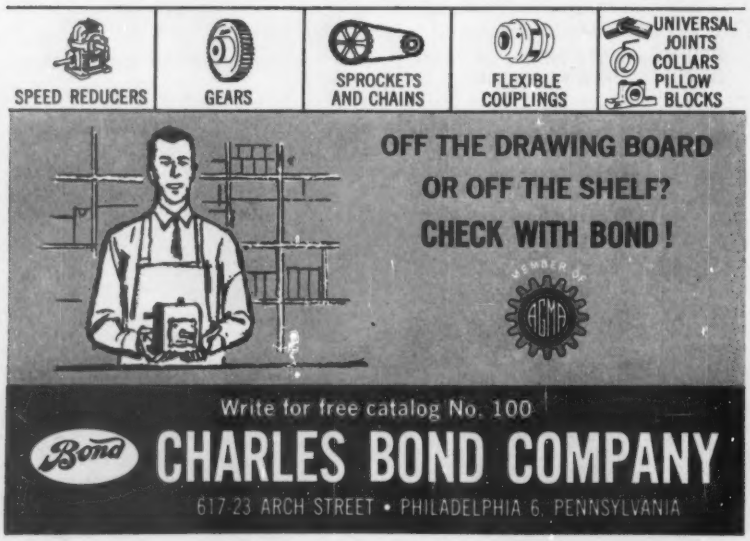
CHAR-LYNN CO.
Hydraulic Horsepower Products
Dept. M211
2843 26th Avenue South
Minneapolis, Minnesota
PArkway 1-5761

Circle 532 on Page 19

DESIGNED FOR THE DESIGNER

Bond Stock Power Transmission Equipment is routinely selected as integral components for new machine designs. Design experts find it saves time and money to check with Bond first before creating special equipment to solve a design problem. Frequently it develops that a Bond Stock Component answers the purpose without resorting to a new engineering approach, expensive dies and costly delay.

Should your situation demand innovation, Bond will be happy to manufacture transmission equipment to your specifications. Bond's almost three-quarters of a century in power transmission design provides a world of special experience at your service.



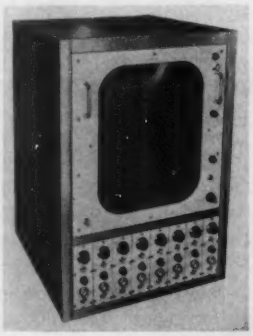
termediates for whiteprint and blueprint equipment, visual projection transparencies, and transferring to diffusion transfer offset plates. Lightweight and completely portable, unit includes a carrying handle. Developing solution is contained in sealed plastic cartridge. It flows into processing tray automatically when unit is turned on and flows back into cartridge when unit is turned off. Dial control of light settings is provided for the varying intensities required for special copying. Unit can be used with any type of diffusion transfer paper, film, and in single-sheet copying system. **Ampto** Inc., Newton, N. J.

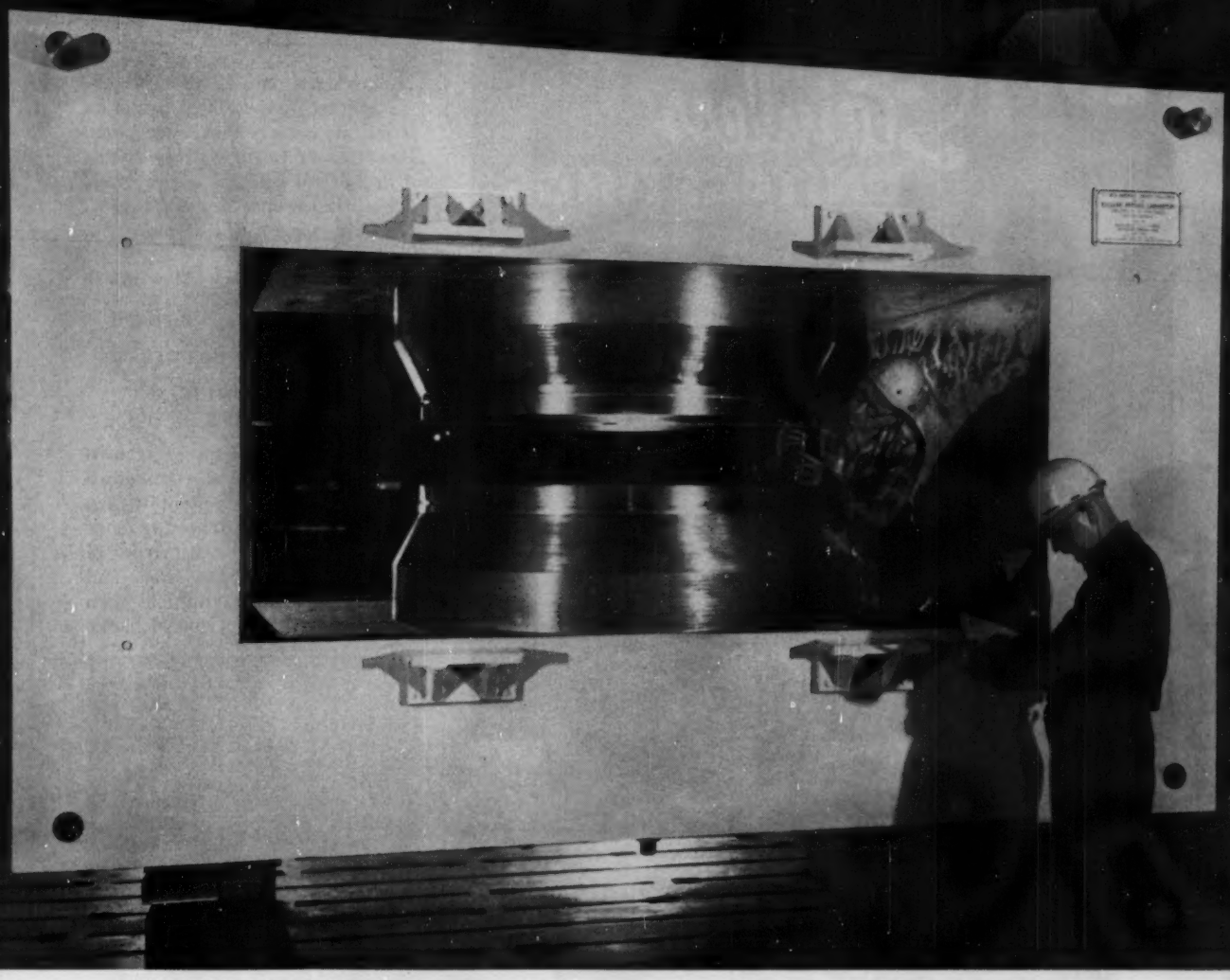
Circle 671 on Page 19

Monitoring Oscilloscope

simultaneously displays up to eight waveforms

Model 769 monitoring oscilloscope simultaneously displays up to eight waveforms on a vertically-mounted 17-in. CR tube. Unit is particularly useful in applications where multichannel oscillographic recording systems are in use, and a means of accurate event monitoring is also desired. Number of traces displayed depends on the number of gating amplifiers used. Entire instrument, including amplifiers, is housed in a single cabinet suitable for table or bench-top use; it is also available for rack mounting.





BETHLEHEM INSPECTORS measure the magnetic gap between the pole pieces of a magnet for the new University of Colorado cyclotron.

85-ton magnet for new research cyclotron forged, machined, and assembled by Bethlehem

The core of a new research cyclotron to be installed by the University of Colorado at Boulder is that 85-ton magnet you see above.

To make this magnet accurate and controllable, Bethlehem had to finish the huge magnet parts to thousandths and to micro-inch finishes. Most critical were the pole tips, which had to be machined to parallelism within 0.004 in. on the 52-in. diameter. They were machined a few thousandths oversize, then the final fitting and machining was done.

The forged pole pieces are tapered on the sides from 59 to 52 in. on the diameter, and are 14.4 in. thick. The yoke members, four of them, were forged in a 7500-ton hydraulic press, then machined to 250-micro-in. with mating surfaces finished to 125 micro-in. They weigh 73 tons, and are held together by large dowel pins and studs. They form a rectangular yoke assembly 142½ in. long, 60 in. wide, and 88½ in. high. The opening measures 96 by 42 in.

When completed, the Boulder cyclotron, a strong-focusing type, will have a capacity range of 10 to 30 million electron volts. The electrons will strike a target when their final speed is built up to 1/8 the speed of light.

Bethlehem Steel Company, Bethlehem, Pa. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 534 on Page 19

A Complete Range of Heat and Corrosion Resistant Steel Castings . . .

Unitcast's 40 years experience as one of the nation's most progressive steel founders, now expands its proved engineering and production facilities to serve the "stainless" market.

Typical of such requirements is illustrated by the fluid pump chamber that pressurizes corrosive liquid. Cast to specification CF-8 (A.I.S.I. 308), this casting will provide long, corrosion-free service to improve the product dependability.

Industrial users of Unitcast's advanced methods in stainless steel as typified by manufacturers that produce oil well equipment, special valves, pumps, compressors and turbines, food processing machinery, dies and fixtures, and heat treating equipment.

An analysis of your needs incurs no obligation on your part. Our technical staff may provide the answer to your problem. Get in touch with us today!

UNITCAST CORPORATION, Steel Foundry Division, Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

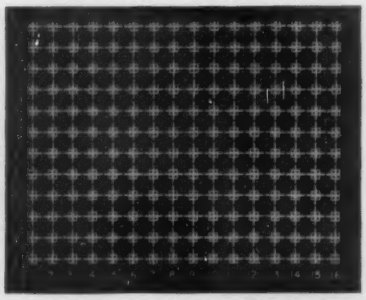
Display screen can be tilted within the cabinet to a 20-deg angle to permit mounting above eye level. Repetitive and single-sweep speeds of 5, 2.5 and 1.25 ips are provided in the oscilloscope. **Industrial Div., Danbury Co., 175 Wyman St., Waltham 54, Mass.**

Circle 672 on Page 19

Prototype Circuit Boards

eliminate major part of point-to-point wiring

Proto-Boards provide specific transistor locating holes and eliminate a large part of point-to-point wiring, terminal boards, or connecting hardware, required with other types of prototype circuit layout. Pads and circuitry are made continuous with a touch of solder. Ground busses



can be located conveniently, depending on design, and plug-in connectors can be used in conjunction with the boards. Many hours of saving are provided in the breadboard stage of circuit design. **Spec-Tronics, 13901 Saticoy St., Van Nuys, Calif.**

Circle 673 on Page 19

Flow Meter

is accurate to 1 per cent over 10:1 range

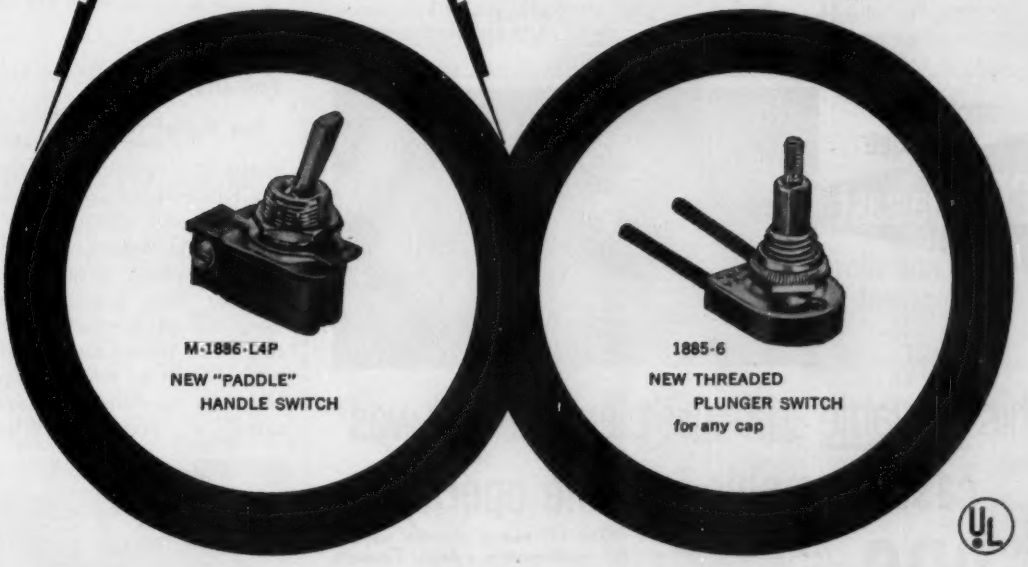
Magnarator combines the functions of an indicating rotameter and a pneumatic transmitter. Instrument measures liquid or gas flows, and is accurate to within 1 per cent over its 10:1 range. Flow travels vertically upward through the metering tube which has no recessed or stagnant areas. Float in the metering tube is magnetically coupled to a rotating follower in the pneumatic transmitter, assuring a positive continuous bond. Dual-reading, 4-in.,

Circle 535 on Page 19

precision engineered control switches

designed with brand new features

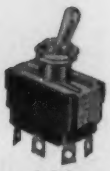
Keeping pace with design engineers, Circle F offers modern control switches for every possible application. New economies are now possible through the use of standard switches readily modified to meet any particular specification. Circle F's advanced standards of quality-controlled manufacture makes possible assembly-line production of highest quality "custom-made" switches in less time and at lowest costs. Whatever your need, write Department S for fullest information and helpful engineering assistance.



M-1886-L4P
NEW "PADDLE" HANDLE SWITCH

1885-6
NEW THREADED PLUNGER SWITCH
for any cap

L-40



L-52

1885

1903

CIRCLE F's "Fine" Silver Contacts reduce arcing on slow-make, slow-break AC and insure long, dependable switch life.

CIRCLE F MFG. CO.

TRENTON 4, NEW JERSEY • For your wire requirements: Eastern Insulated Wire Corp., Box 591, Trenton, N. J.

800 to 1 hp favorites for quiet operation, low maintenance and long-life service . . .

From the case of the A. O. Smith Motor Man — a complete stable of integrals that include single-phase models (1-5 hp) or polyphase (1-800 hp). Also a team of fractional-hp motors. All are sure bets to give top performance over the long, long haul.

And there's an A. O. Smith Motor Man near you — chomping at the bit to give you 24-hour action on all parts and service orders.

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Through research ...a better way

A.O.Smith CORPORATION

ELECTRIC MOTORS

Tipp City, Ohio

A. O. SMITH INTERNATIONAL, S.A.
Milwaukee 1, Wisconsin, U.S.A.

Circle 537 on Page 19

another unique GRC die cast zinc alloy component

this movable Intercast® element unit was cast-assembled in one operation by GRC

GRC'S unique, patented INTERCAST method die casts multiple-part zinc-alloy units with moving elements in a single, automatic, time-saving, money-saving operation . . . even continuously interlocked assemblies. Units leave the machine complete, ready for immediate use.

This INTERCAST technique is an ingenious refinement of GRC's exclusive method of small parts die casting—providing broad design latitude, close tolerances, economies in quantities of 100,000 and more.

Let GRC solve your problems. No size too small. Maximum length: 1¾", maximum weight: ½ oz.

Send for samples, prices and fact-filled bulletin, TODAY.

World's Foremost Producer of Small Die Castings

GRIES

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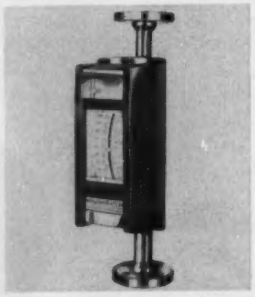


vertical output scale indicates flow rate and transmitted pneumatic signal which is linear. Horizontal reading scale shows float position independent of the air supply and transmitter output. Single-model transmitter can be used with any metering tube ½ to 2-in. in diam covering flows equivalent to 1 to 100 gpm water and 4 to 400 scfm air. Metering tube and float construction materials depend upon fluid conditions. **Fischer & Porter Co.**, 676 Jacksonville Rd., Warminster, Pa.

Circle 674 on Page 19

Volt-Ohmmeter

has digital readout

Model 61 Digimeter volt-ohmmeter is a battery-powered instrument for the precision measurement of dc voltage and resistance. It features digital readout, long battery life, freedom from power-line connection, and an accuracy of ±0.1 per cent. A potentiometer circuit is used for voltage measurements, and resistance measurements are made using a precision Wheatstone

Bridge, the 10-turn potentiometer being employed as the comparison arm. Separate terminal on the panel provides a precision output voltage of 0 to 100 mv and 0 to 1 v for external use. Dual-purpose

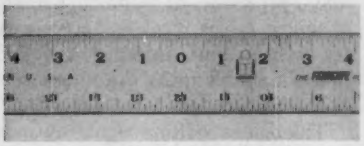
carrying handle of the portable unit doubles as a bench stand when loosened by thumb screws and swung under the instrument. **F. W. Bell Inc.**, 1356 Norton Ave., Columbus 12, Ohio.

Circle 675 on Page 19

Measuring Rule

measures outward in two directions

C-24 measuring rule begins in the center of the rule and measures outward in two directions, thus quickly splitting distances in half.



Unit is hard aluminum and has a straight edge. **Fairgate Rule Co. Inc.**, Cold Spring, N. Y.

Circle 676 on Page 19

Reproduction Films

provide high legibility and balanced translucency

Three high-contrast Kodagraph films offer excellent durability and dimensional stability to reproductions of drawings, maps, and other documents. Reproductions have high legibility, balanced translucency for fast print-back, excellent drafting surface, and moisture resistance for fast drying. Films are available in rolls for drawing up to 52 in. Autopositive film, Estar base, provides a same-size positive reproduction of the original drawing or other positive copy without a negative step. Contact film, Estar base, produces positives of outstanding crispness and legibility from paper or film negatives, is excellent for making same-size reproductions of old or weak line drawings, maps, and other documents. Projection film, Estar base, has high-contrast emulsion which produces crisp, clean results. It is especially designed for projection printing of enlargements or reductions from film negatives. **Graphic Reproduction Div., Eastman Kodak Co.**, Rochester 4, N. Y.

Circle 677 on Page 19

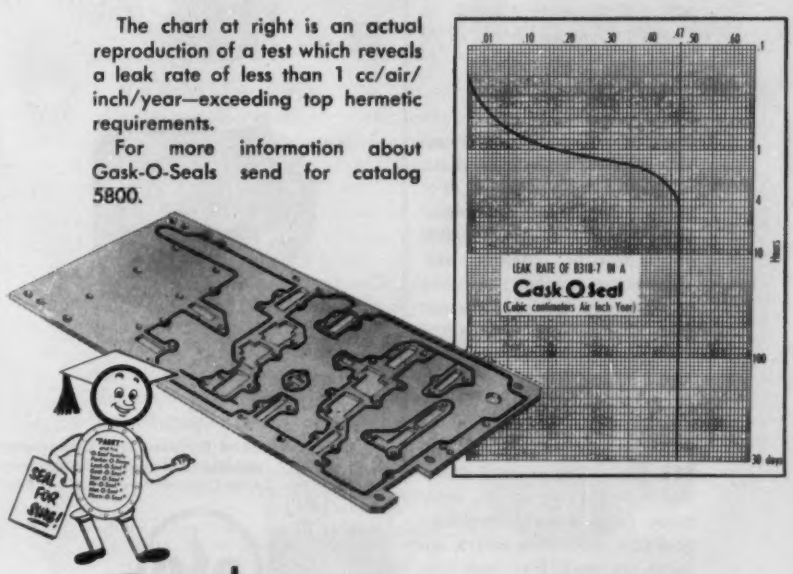
YOU CAN SEAL VACUUM and still get serviceability!

Gask-O-Seals meet, or exceed grade A MIL-8484 specifications for hermetic sealing, yet they are mechanical. That means you can seal a vacuum and still achieve full serviceability — easy access for repair, maintenance, re-setting, etc. You can seal components, "black-boxes," instruments, even complete systems — and re-seal them with the *same* seal!

The seal shown below illustrates the versatility of Gask-O-Seal — one piece seal actually doing the job of ten! Think of the freedom of design such a seal offers. Can they be put to use for your products, too?

The chart at right is an actual reproduction of a test which reveals a leak rate of less than 1 cc/air/inch/year—exceeding top hermetic requirements.

For more information about Gask-O-Seals send for catalog 5800.



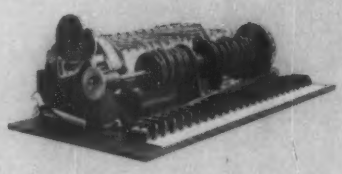
Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

Parker also makes Seals for Wave Guide Flanges that prevent R/F leakage and provide a positive no-leakage seal; a self sealing flush-head rivet called Riv-O-Seal, and many other specialized seals as well as O-Rings and Back-up Rings. Your inquiry is invited.

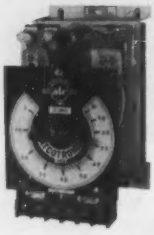
Circle 539 on Page 19

TIMERS

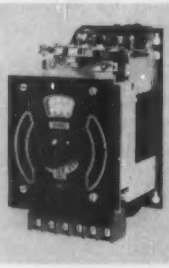
Multi-Circuit Cam Timers control sequence and duration of one or a series of operations. Time cycles from ⅔ of a second to 7 days. Controls 1 to 100 circuits in any length of "made" or "broken" periods desired. Choose either Repeat or Stop Cycle operation. **Series 2400**



Electronic Timers provide high accuracy and constant, exact repeatability for intervals from .02 to 120 seconds. Unaffected by vibration, tube aging, line voltage fluctuations. Printed circuit design, few mechanical parts mean long life at fast, repetitive cycling. **Series 5200**



Heavy Duty Reset Timers automatically and instantly reset on power interruption. SPDT heavy duty load contacts carry 25 amps. Available for vernier adjustment or cycle progress indication. **Series 2800**



Revolution Counters count shaft revolutions at speeds up to 1000 rpm, with only 1¼ oz. in. torque on input shaft. For measuring, product counting or cut-off, fluid metering, drill depth control, indexing, etc. Ideal where process variations occur and pulse count is not adequate. **Series 307**

IF IT'S A TIMING PROBLEM, SEE ATC. Wide product selection includes cam timers, automatic reset timers, revolution counters, electronic timers, impulse counters, transistor timers, many others.
Special timers and counters designed to your requirements.

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THE ENGINEER'S Library

Recent Books

Handbook of Chemistry and Physics—42nd Edition: 1960-1961. *3481 pages, 5 by 7½ in., clothbound; published by Chemical Rubber Publishing Co., 2310 Superior Ave., Cleveland 14, Ohio; available from* MACHINE DESIGN, *$12.00 per copy postpaid.*

Mathematical tables, properties and physical constants, general chemical tables, heat and hygrometry tables and information, and quantities and units are major sections. All sections are indexed.

This latest edition contains new tables on standard types of stainless steel, diffusion of metals into metals, initial permeability of high-purity iron at various temperatures, and others. Revised, expanded, and updated data and information cover trade names of plastics, properties of refractory materials, efficiency drying agents, atomic weights, and others.

Organizational Systems and Engineering Groups: A Comparative Study of Two Technical Groups in Industry. *By Louis B. Barnes, assistant professor of business administration, Harvard University;* 190 *pages, 5½ by 8¼ in., clothbound; published by Division of Research, Harvard Business School, Soldiers Field, Boston 63, Mass.; $3.50 per copy.*

This book discusses the relationship between various attributes of organizations and their consequences for group development, productivity, and satisfaction of engineers and other technically trained employees. Two technical groups were comparatively analyzed.

Topics include effect of pattern of authority on behavior of engineers in work groups; effect of different degrees of individual and group autonomy on motivation, productivity, and satisfaction of engineers; effect on group development of a relatively free—or restricted—opportunity for interaction among engineers; and effect of conflicting values of science and business on group development,

productivity, and satisfaction within different organizational environments.

Engineer's Vest Pocket Book. *By W. A. Thomas, H. A. Spalding, and Zarko Pavlovich; 192 pages, 2¾ by 5½ in., clothbound; published by Ottenheimer Publishers Inc., 4805 Nelson Ave., Baltimore 15, Md.; $0.90 per copy.*

General engineering information is contained in the 250 main items and 47 charts. Properties of structural steel, strength of gear teeth, thermal stress, properties of minerals, binomial theorem, resistance of immersed body moving through fluid, and various other engineering data are included.

Introduction to the Gas Turbine. *By D. G. Shepherd, professor of mechanical engineering, Cornell University; 300 pages, 6 by 9½ in., clothbound; published by D. Van Nostrand Co. Inc., New York, N. Y.; available from* MACHINE DESIGN, *$7.75 per copy postpaid.*

Emphasis is placed on fundamental principles of gas turbines rather than details. Only a knowledge of elementary thermodynamics and fluid flow are necessary to an understanding of material.

Cycle analysis is thoroughly discussed. Chapters on components are unified to give a knowledge of main elements for assessment and understanding of performance. Both existing and possible future applications of gas turbines are reviewed.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161443. Composite Materials and Composite Structures—Proceedings of the Sixth Sagamore Ordnance Materials Research Conference. 549 pages, 8½ by 11 in., paperbound; $7.00 per copy.

Fundamentals, most recent advances, and probable future developments in the field of physical, metallurgical, and mechanical behavior of composite materials and composite structures are presented. Special consideration is given to theories, design requirements, and fabrication techniques of metallic and nonmetallic composite materials and structures under consideration for Ordnance applications. Scope of the conference included metallic composites, glass-reinforced plastics, laminated and other plastic structures, and materials for ablating composites.

PB 161543. Some Elevated Temperature Properties of Precipitation Hardenable Iron-Aluminum Alloys. By W. J. Buehler and C. G. Dalrymple; 16 pages, 8 by 10½ in., paperbound, side-stapled; $0.50 per copy.

Effects of titanium and titanium plus carbon on elevated temperature properties of binary iron-aluminum alloys were studied. Tensile and stress-rupture tests are discussed.

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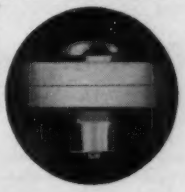

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Circle 541 on Page 19

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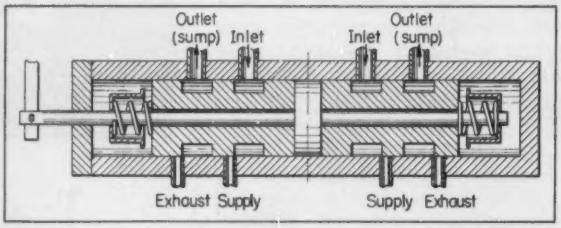
NOTEWORTHY

Patents

Self-Clearing Valve

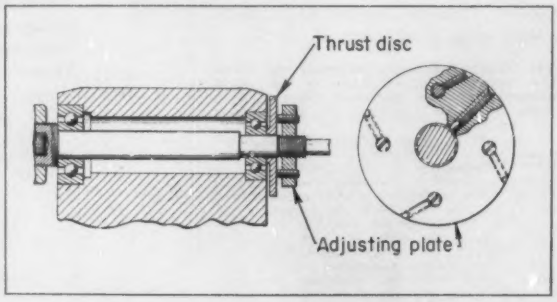
Two independent valving elements compensate for flow-control errors introduced by jamming in a high-performance servo valve. When one valve element jams open, a control piston positions the other valve



element to correct the flow error. When, upon demand, the jammed element is reopened, the obstruction is washed away, clearing the valve. *Patent* 2,953,163 *assigned to Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., by Frank W. Ainsworth.*

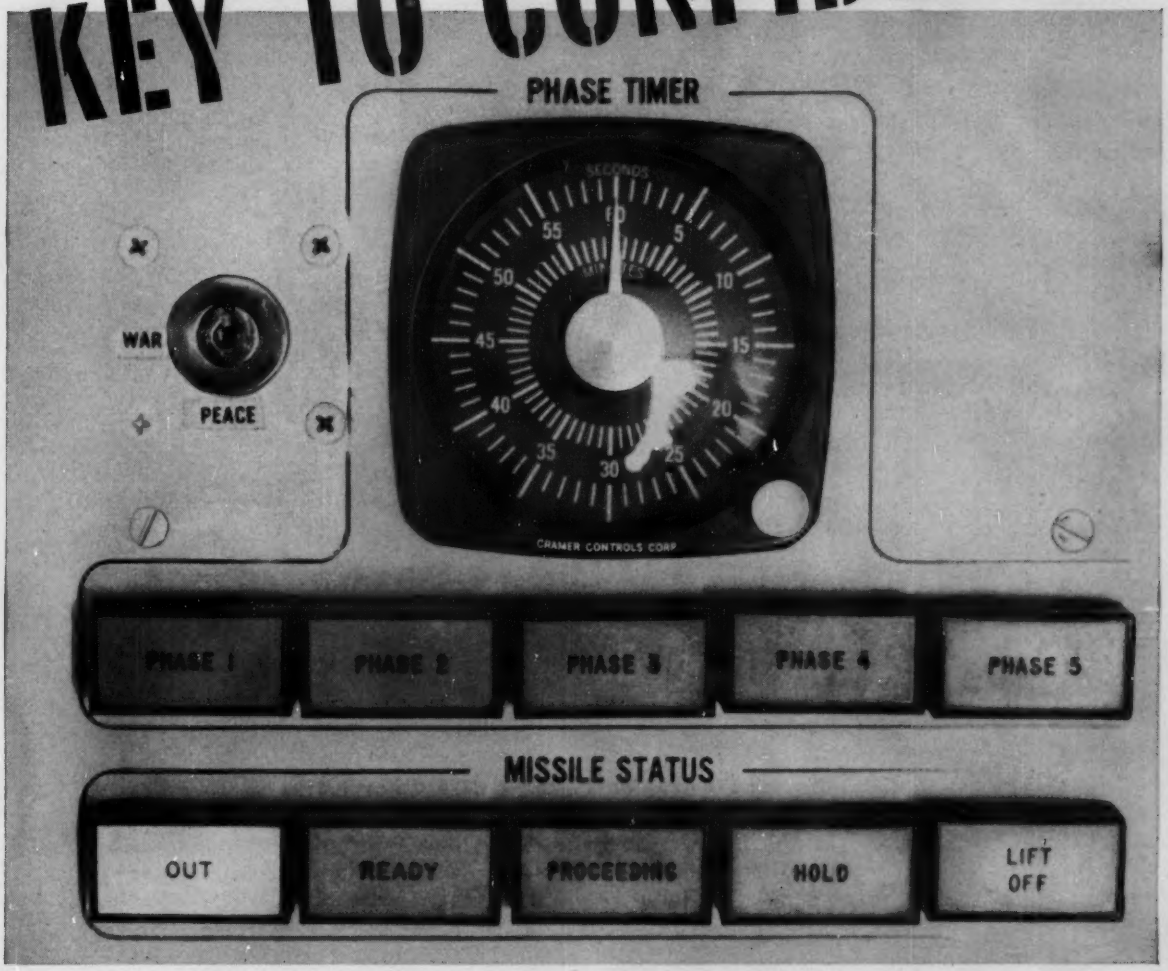
Booster-brake mechanism for pedal-operated hydraulic braking systems provides two stages of reaction against the pedal. In the initial stage of brake-pedal operation, before the brake shoes contact the drums, resistance to pedal movement is reduced. After the shoes contact the drum, a higher degree of pedal reaction is provided. Reaction pressures at the pedal are controlled through a small auxiliary piston which is inoperative during the initial stage, but is actuated by pressure buildup in the system produced by shoe and drum engagement. *Patent* 2,952,978 *assigned to Kelsey-Hayes Co., Detroit, Mich., by William Stelzer.*

Adjustable Bearing Assembly



Play, vibration, and objectionable noise in rotating shaft assemblies are eliminated with an adjustable bearing arrangement. Designed for use with antifriction bearings, the construction uses an adjusting plate and thrust disc to control bearing preload and align-

KEY TO CONFIDENCE



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This is a ballistic missile control panel, somewhere in England. You may have seen it in a recent issue of either of two leading weekly news magazines . . . and read about two keyslots: "War-Peace", to permit activation of the atomic warhead, and "Launch Sequence", to initiate the intricately synchronized steps that lead to lift-off.

Once that sequence is started, each of the five phases of the 15-minute countdown is completely automatic, precisely indicated by a Cramer Type 691 Time Totalizer. Human hands begin the cycle, and may stop it before the fateful last minute. But no hands are deft enough to guide it through its complex dance.

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Time Ranges: 60 seconds or 60 minutes. Outer scale reads either seconds, .01 second, or .01 minute intervals.

Motor Ratings: all standard voltages at 50, 60 or 400 cps, and 28v DC chronometrically governed.

Accuracy: within .01 second or .005 minute.

Reset: in 1/10 second, by dial pushbutton or remote control.

Load Switches: Optional. SPDT, rated 5 amps at 115 and 230 volts, AC or 2 amps at 28 volts DC.

Cams: Optional, to operate load switches. Cut to user requirements.

MIL-Specs: Hermetically sealed military units meet vibration, shock and environmental tests of MIL-E-5272B.

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Circle 543 on Page 19

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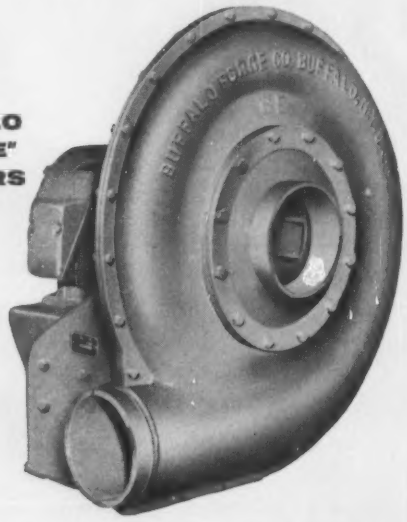
BUFFALO TYPE "E" BLOWERS



For medium-volume, medium-pressure applications, there is no better buy than "E" Blowers. Husky housings, interchangeable for clockwise or counter-clockwise rotation. Wheels available in Cast Iron, Stainless, Everdur, Brass or Aluminum. Capacities to 5500 cfm; pressures to 1¾ psi. Compact, direct-connected arrangement for best installation. Write for Bulletin FI-410 and judge for yourself.

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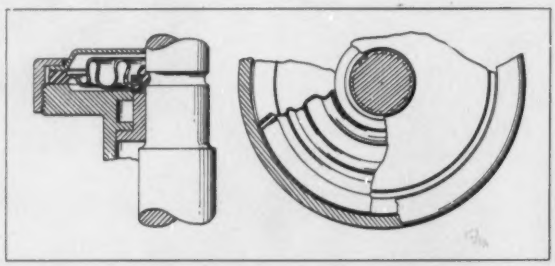
ment. The thrust disc, which is mounted to the shaft between a bearing and the adjusting plate with a sliding fit, engages the inner race of the bearing through a flanged neck at the ID. The adjusting plate is threaded onto the shaft and carries several adjusting screws which protrude from the face of the plate to engage the thrust disc. Accurate adjustment of bearing preload and alignment is obtained by varying the thrust-disc position with the plate-and-screw assembly. Position adjustments of the plate and its screws are locked by set screws. *Patent* 2,953,417 *assigned to Horberg Grinding Industries Inc., Bridgeport, Conn., by William Horberg.*

Oscillating-Shaft Oil Seal

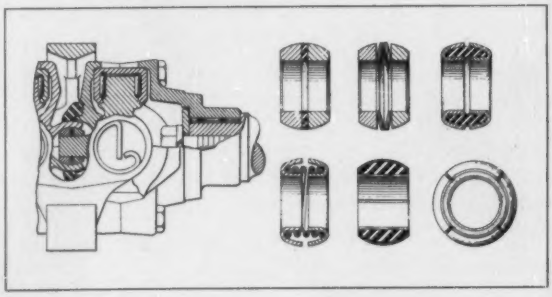
Leakage of lubricant from an oscillating shaft is prevented by a thin diaphragm of rubber, neoprene, or other flexible and elastic material. The diaphragm is



clamped to both the shaft and the housing. Folds in the diaphragm material make possible relative angular movements between the shaft and the housing of as much as a revolution and more. *Patent* 2,950,499 *assigned to Schlage Lock Co. by Ernest L. Schlage.*

Pneumatically actuated relay controls operation of electrical contacts by balancing a control pressure against a measured or set pressure. The set pressure can be varied to meet application requirements. Relay units can be stacked to provide multiple switching elements which respond to predetermined levels of a pressure supplied to one connection. *Patent* 2,953,657 *assigned to Moore Products Co., Philadelphia, Pa., by Thomas William Clements.*

Universal-Joint Expansion Ball



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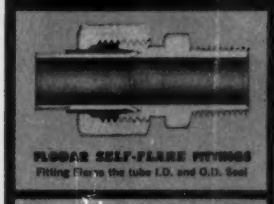

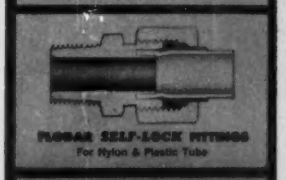

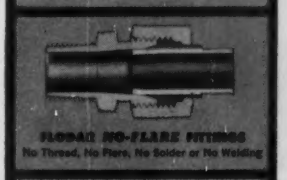

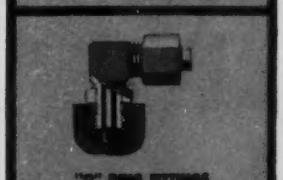

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Ingredient Container for Coffee Dispensing Machine, drawn from 20 gauge 302 — 18-8 stainless steel.

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If you are working on new designs, or have run into troublesome technical problems on what you are already doing, there's a very good chance that Polar engineers and Polar facilities can give you positive help — in stainless steel, carbon steel or aluminum. Please address your inquiries to the Contract Department.

Container for food dispensing use, drawn from 20 gauge, stainless steel.

Stock pot drawn from 10 gauge aluminum.

Polar Ware Co.
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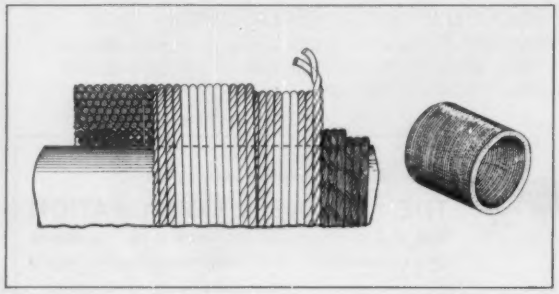
construction minimizes relative movement between pilot-shaft extension, ball, and socket element to reduce impact under changes in load. The centering ball is made up of separable sections which are spaced by a resilient material so that the assembly may expand or contract to meet clearance and take-up requirements. *Patent* 2,953,001 *assigned to General Motors Corp., Detroit, Mich., by Gibson O. Hufstader.*

Molded-Resin Bearings

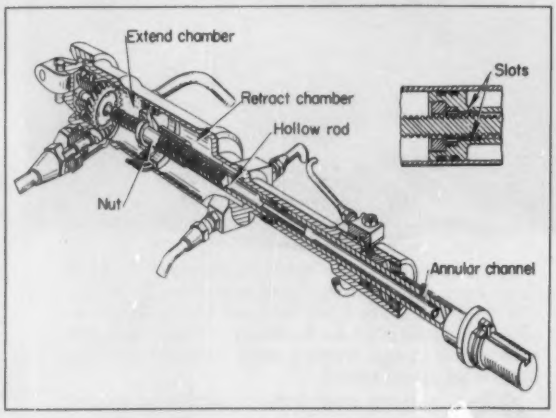
Plastic bearing for instrument and similar applications is formed of layers of wrapped yarn. Inner bearing core is made up of a pair of crossed helical-wound layers of multiple-filament Teflon yarn impregnated with a thermosetting bonding resin. This core has a backing of several layers of heat-shrinkable yarn, such



as nylon or Dacron, which is also resin impregnated. Heat curing shrinks and bonds the outer nylon or Dacron yarn layers to form a rigid tubular shell which holds the inner low-friction Teflon-yarn bearing surface in position. *Patent* 2,953,418 *assigned to The Russell Manufacturing Co., Middletown, Conn., by Leslie A. Runton and Henry C. Morton.*

Fluid-Cooled Hydraulic Actuator

Part of the system's hydraulic fluid flows through the piston rod of a hydraulic actuator to cool the assembly during operation in high ambient temperatures.



When fluid is forced into the extend chamber, a metered amount flows into the hollow piston rod through slots in the nut which secures the piston to the

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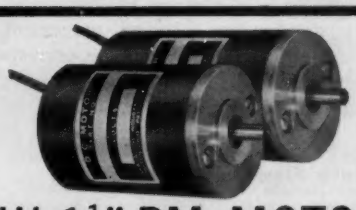

NEW 1½" PM MOTORS

These two 1½" diameter permanent magnet d.c. motors pack the kind of hefty torque you want to replace larger, less efficient motors. Use them alone, with a governor, a brake, or a Globe precision planetary gear reducer (101 standard ratios, up to 1000 oz. in. output torque). Each has 21 standard windings from 4 to 115 v.d.c.; custom building to your exact specs is simplified. Designed to meet the roughest MIL specs.

TYPE BL: 1½" dia. x 2 15/16" max. length. Weight 11¼ oz. Continuous duty rating is 1/30 hp. @ 10,000 rpm. Intermittent torque output is 8.0 oz. in. Speeds to 13,300 rpm.

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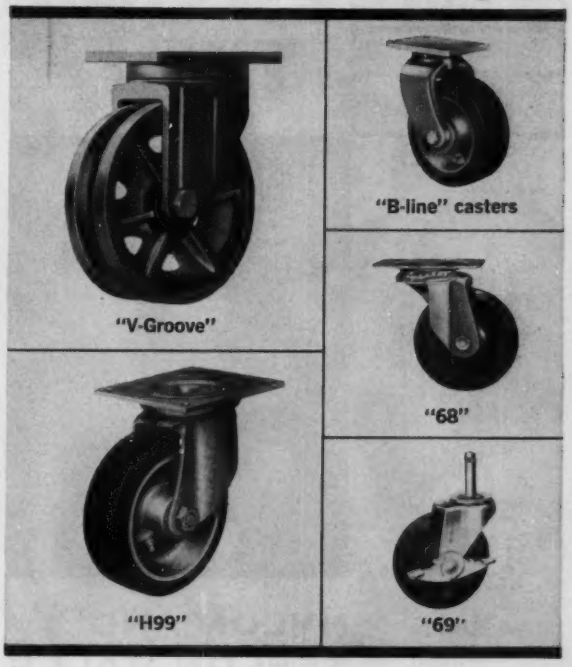
You can operate both motors within 0.1% speed accuracy with Globe's new electronic governor or within 2% with a mechanical governor. Request Bulletin BDL-205 from Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

GLOBE INDUSTRIES, INC.

Circle 550 on Page 19

DESIGNERS:



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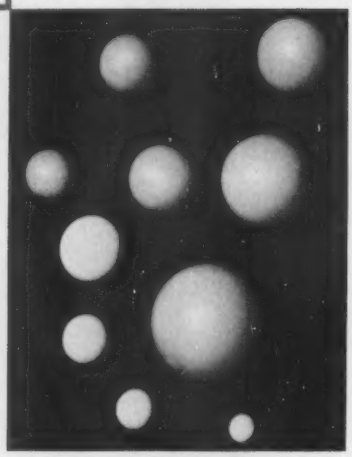

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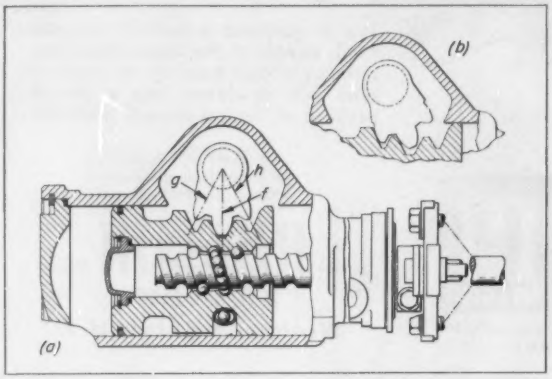
screw shaft. From the end of the rod, the cooling fluid passes through an annular channel to cool the entire length of the piston rod. Ducts carry the coolant to the retract chamber and from there to the drain line. *Patent 2,955,574 assigned to General Motors Corp., Detroit, Mich., by Howard M. Geyer.*

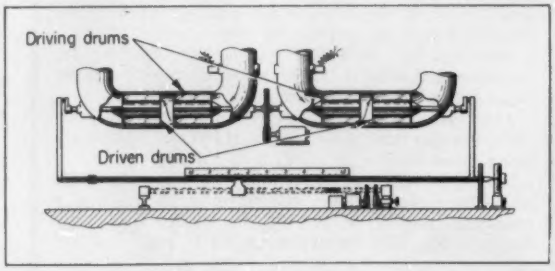
Variable-Ratio Power-Steering System

Steering gear uses a rack piston in conjunction with a gear sector to provide a variable ratio. With the front wheels in a straight-ahead position, *a*, moment arm *f* provides maximum mechanical advantage. As the piston and sector are displaced from their center position, *b*, the mechanical advantage decreases because the effective lever arm is shortened (*g*, *h*). Thus, the angular displacement of the sector becomes progressively greater for a given movement of the piston, and the effort required becomes correspondingly greater. *Patent 2,953,932 assigned to General Motors Corp., Detroit, Mich., by Clovis W. Lincoln.*



Variable-Rate Flow Regulator

A system for regulating or measuring the flow of two fluids in separate lines uses the principle of angular momentum exchange. A pair of driving drums, with attached vanes, impart angular momentum to the fluid in the inlet passages. Pickup drums, also vaned, transform the helical flow of the fluid to axial flow. Energy absorbed by the pickup drums produces a torque, which is transmitted through a bell crank and line assembly to an indicator bar. This bar rotates on a fulcrum through an angle determined by the torque exerted on either end, and the position of the



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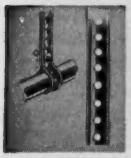
BLACK NYLON CABLE CLAMPS

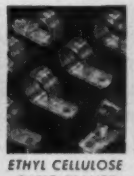
BLACK NYLON SNAP CLIPS

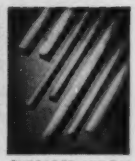
BLACK NYLON HALF CLIPS

WEDGE LOCK BAND CLAMPS


PERFORATED BLACK NYLON STRAPPING

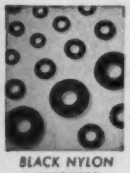
TEFLON CABLE CLAMPS


ETHYL CELLULOSE CABLE CLAMPS


THREADED NYLON ROD

MOLDED BLACK NYLON SCREWS

BLACK NYLON CAP NUTS


BLACK NYLON WASHERS

"D" WASHERS

WRITE FOR FURTHER DETAILS, SPECIFICATIONS AND PRICES

Weckesser COMPANY

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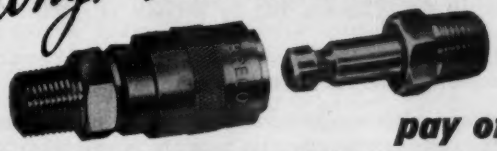
Circle 553 on Page 19

Why QUICK DISCONNECTS pay off



Because Quick Disconnects are the **fastest, easiest** and **most economical** means of making or breaking a connection. They pay for themselves by reducing costly set-up time and maintenance costs.

A simple, one-hand operation—**connect or disconnect lines instantly.** No turning or twisting. Eliminates costly "wrench type" connections. Step-up production.

The Series "D" (2D & 4D) Couplings are **interchangeable** with all popular makes. A small, rugged lightweight coupling for air, liquids and gases. Designed for instrumentation, aircraft and industrial uses. Construction and performance meets Military Specification MIL-C-4109A.

Patented **PUSHOMATIC** locking forms a positive high-pressure and leak-proof connection. Buna N seals assure positive sealing. Shut-off valve in socket stops the flow when disconnected. Working Pressures to 7500 PSI.

The Series "D" has these **advantages**

Automatic Locking — **360° Swivel action**
One-hand Operation — **Integral shut-off valve**
Interchangeability

Four end types in pipe sizes ⅛" through ¾" N. P. T.
Write for Interchangeable Coupling Bulletin 1500.

where *Good Connections* count!

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Circle 554 on Page 19

HEAVY-DUTY LIMIT SWITCHES

KLBP-RH

For motor loads
2 HP 250 v.a-c
1 HP 125 v.a-c

For heater loads
20 amperes 125/250/480 v.a-c

For lamp loads
10 amperes 125 v.a-c (tungsten-filament)
UL listing.

Mechanical Features

Sturdy die-cast housing with threaded hub

Right- or left-hand mounting

Removable, "O"-ring-sealed cover with captive attachment screws

All wiring connections made with switch outside housing

Sealed actuators

Adjustable roller-arm or hand-operated actuators

Roller-plunger actuators

KLBC-RH

KLB-RH

KLR-RH

Write for Bulletin B-30 that gives details and useful application data.

UNIMAX SWITCH
Division, The W. L. Maxson Corporation
IVES ROAD, WALLINGFORD, CONNECTICUT

Circle 555 on Page 19

NEW PISTON PRESSURE SWITCH

CONTROLS 2 INDEPENDENT ELECTRICAL CIRCUITS

Really TWO pressure switches for the price of ONE

7000 P.S.I. PROOF

*With calibrated dials (both settings can be made visually without gauges). Without dials $29.50. Both prices subject to the usual quantity and trade discounts.

WE BUILD IN	WE DON'T USE
RUGGEDNESS CAN TAKE SURGES (High proof pressures) CONTINUOUS OPERATION (Millions of cycles) NO STICKING (in dirty fluid)	LINKAGES & BEARINGS WHICH WEAR QUICKLY (cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS NO RETURN DRAIN PIPING (Sealed piston) MOUNTS WHERE CONVENIENT (Operates in any position, not sensitive to vibration)	UNSEALED PISTONS WHICH ADD TO YOUR INSTALLATION COST (return piping). ARE CRITICAL TO DIRT (pistons get stuck).

PRESSURE SWITCH DIVISION

Barksdale valves

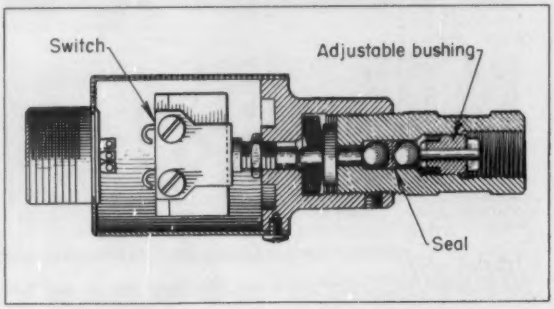
Send for FREE catalog 9-PS.

5125 Alcoa Avenue, Los Angeles 58, California

fulcrum. Adjustment of the fulcrum is made either automatically, or by a hand-wheel. The bar can be linked to the fluid lines by a valving arrangement to permit measurement or control of flow ratio. *Patent* 2,953,920 *assigned to Aerojet-General Corp., Azusa, Calif., by Sigmund H. Machlanski.*

Extreme-Condition Actuator

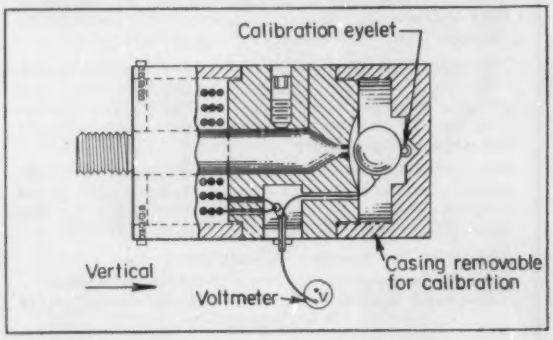
A specially constructed Teflon spacer in the inlet port of a hydraulic actuator provides a positive seal for high-temperature, high-pressure applications. When pressure is applied to a ball in the inlet chamber, the spacer is compressed axially against a second ball, providing increased sealing pressure against the sides.



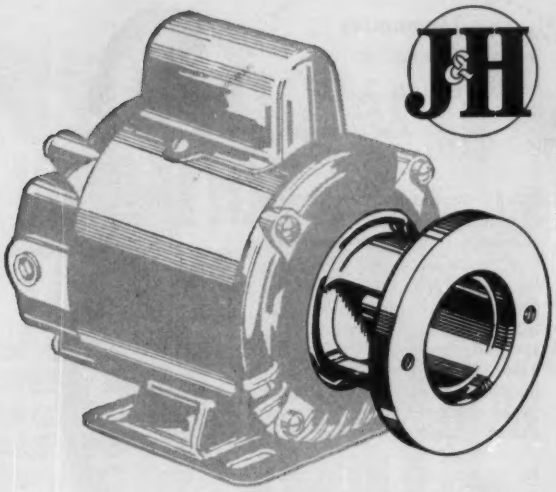
Cone-shaped depressions on each side of the spacer position the balls and insure greater lateral expansion than would be available with a flat disc-type spacer. Ball movement is controlled by an adjustable bushing set in the inlet port. *Patent* 2,955,618 *assigned to Cook Electric Co., Chicago, Ill., by William H. Miller.*

Magnetic-Contact Accelerometer

A springless accelerometer uses a ball in a magnetic seat to measure acceleration peaks in ranges above one g. After the meter has been mounted, current from an oscillator is passed through the ball. As long as the ball is seated, the signal is shorted back to the oscillator.



When the calibrated acceleration is reached the ball is unseated and the short circuit is opened. The voltmeter in the circuit then ceases to register, indicating that the calibrated acceleration has been reached. *Patent* 2,955,470 *assigned to the United States of America by Marcus G. Comuntzis.*



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Right at this coupling, there is a meeting of minds between pump designer and motor designer. Jack & Heintz can build the drive end to suit your individual requirements for mounting, alignment or coupling—just like that!

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In fact, whatever your specs, Jack & Heintz can deliver a *smaller, lighter motor* than any conventional motor. And . . . eliminate all alignment problems!

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HORSEPOWER: ½ to 1½ single phase, ½ to 2 three phase
SPEEDS: 3450, 1725 or 1140 rpm
FRAME: J66 or special
ENCLOSURE: Open or totally enclosed, or special
BASE: Standard NEMA, or special
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Customized
JACK & HEINTZ
ELECTRIC MOTORS

Circle 557 on Page 19

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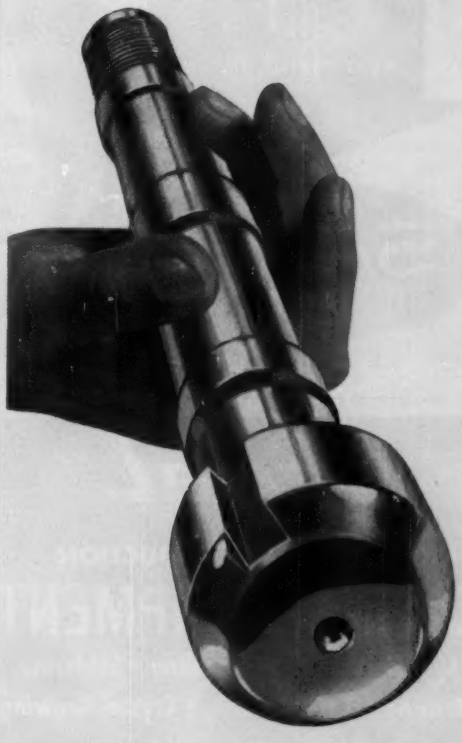

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(metalformed, that is!)

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Spinnings, like women, come in all shapes and sizes. But when you have man-sized equipment and years of experience, even the most resistant conformations fall into line. Spincraft has that equipment in its exclusive, specially-built MET-L-FLO automation lathes — available nowhere else. It has the experience, forty years of creative metal-spinning.

In rockets and missiles, Spincraft has been there from the beginning. The sheath dress the lady is wearing is actually a thrust nozzle for the early Hermes missile. The trapeze dress is a section of the Honest John rocket. And the chemise is the preform stage of countless spinning jobs in missile and other fields.

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ELECTRONIC TUBE GENERATORS:
1 kw; 2½ kw; 5 kw; 10 kw;
20 kw; 30 kw; 50 kw;
75 kw; 100 kw.

SPARK GAP CONVERTERS:
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15 kw; 30 kw.

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ZERO-MAX

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Three Types:

1. *Light Duty*—Compression Ult. Load 1250 lbs.; Ult. tension 960 lbs.
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Positive remote controls for actuating mechanical, hydraulic or other devices. Eliminate bell cranks, pulleys and dual cables. U. S. Patent No. 2441719. All world rights reserved. Send for ENGINEERING MANUAL No. 1551 giving complete specifications covering materials, finishes, capacities. Please address Dept. MD-PP-60.

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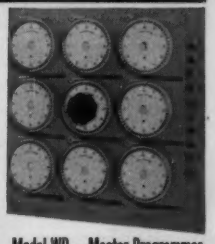
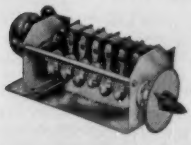
NOW . . . A New Design Concept in Multi-Circuit Program Control

ZENITH Multi-Circuit TIMERS



Model WD—Master Programmer

Master programming dials control operation of all circuits and sequencing relationship between circuits in the cycle. Adjustments are easily made on the face of the panel. As many as 48 "on" and "off" operations can be made on any one circuit without disturbing operation of other circuits. Single heavy-duty motor drives entire unit to assure full synchronization of operations and dials.



Model WM—Compact Design

Zenith Multi-Circuit Cycle Timers are available in models and types for all timing, mixing, compounding, processing and similar operations. They can be supplied in any time cycle and any number of switches.

Request details on the Zenith Master Programmer and other multi-circuit timers. Write on company letterhead for complete 64-page catalog describing automatic transfer and remote control switches, magnetic contactors, program clocks and timing controls.

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SAVE TIME

WITH KAMLOK QUICK COUPLERS

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Fastest — safest — surest couplings known.

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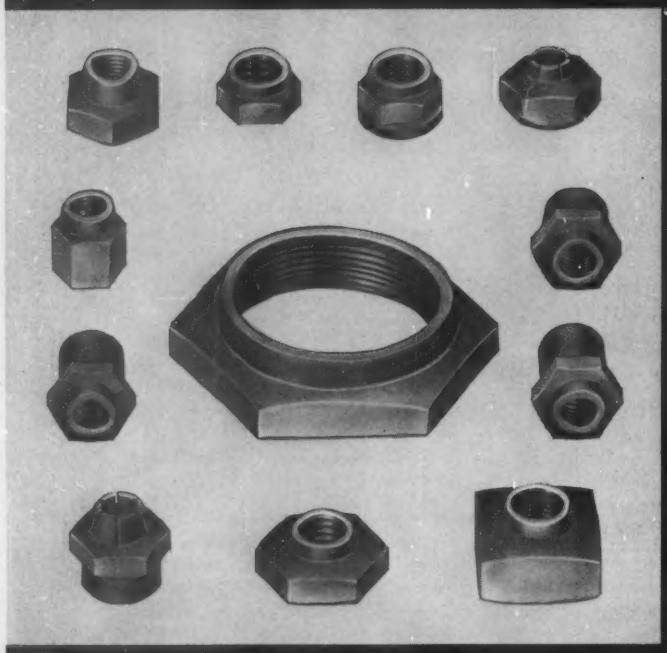
SPECIAL LOCKNUTS . . . *that solved fastening problems*



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Manufacturers of Standard and Special ferrous and non-ferrous Hexagon, Square and "12 Pointer" nuts . . . "Conelok," "Huglock" and "Marsden" locknuts.

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- **Protect against thread damage, dust, dirt, and moisture.**
- **For inside and outside application. All sizes. Immediate delivery.**

METAL Caps to cover AN & SAE threads

PLASTIC tapered caps and plugs

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No. 5 of a Series

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Gear Case Cover

RCA-Whirlpool Imperial Mark XII Automatic Washer

PARAMOUNT—a major supplier of die castings to Whirlpool Corporation for 15 years

Whirlpool quality is recognized throughout the world, quality which stems from the rigid quality standards which Whirlpool demands that its suppliers meet.

Paramount's engineering and production "know-how", its ability to consistently meet Whirlpool's exacting quality standards—as in these die castings for the RCA-Whirlpool Imperial Mark XII Automatic Washer—are the reasons why Paramount has consistently been one of Whirlpool's major suppliers for 15 years.

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If your product incorporates die castings or you're considering them—investigate Paramount's complete services.

Three complete plants—two in St. Joseph, Mich., one in Seymour, Indiana.

SEND For "Designing for Die Casting"

PARAMOUNT *Die Casting Co.*

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Circle 567 on Page 19

(Advertisement)

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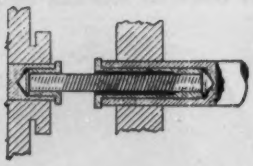

Coupling is used for the transmission of power or control of movement between parts located close together in a piece of equipment. It is not a separate type of flexible shaft but rather an added application of flexible shafting.

The coupling can be composed of either mono-directional or bi-directional or flexible shafting although the latter is generally used due to the added advantage of its ability to rotate both clockwise and counter clockwise. Generally used between two units which are but a few inches apart, coupling may transmit power between any two parts regardless of their relative positions.

For example, the diagram above shows an advantage in using small lengths of flexible shafting in a coupling application. Although the drive end and the driven end are not exactly in line, the coupling compensates for the difference in alignment between the two.

Many manufacturers use flexible shaft coupling even where parts may be connected by solid shafts because of the savings realized in the initial and the maintenance costs as well as in time and labor.

For complete information on how flexible shaft couplings may help improve your product design, write **F. W. Stewart Corporation, 4311-13 Ravenswood Avenue, Chicago 13, Illinois.**

Circle 568 on Page 19

SOLENOID VALVES
can you afford the
HIGH COST of Low Price Tags ?

Entire production systems depend on the successful operation of control instruments like solenoid valves.

Malfunction or failure of a solenoid valve causes downtime and loss of production monstrously out of proportion to the cost of the valve itself.

When you're tempted by an alluring low price tag on a solenoid valve, think ahead. Will the few dollars you save pay for the downtime and the service and replacement costs?

Atkomatic solenoid valves are a far-sighted investment in system-wide efficiency. Atkomatic manufactures a full line of bronze and stainless steel valves for all media in pressure groups ranging from zero to 10,000 psi.

Write today for Catalog No. 444.

ENGINEERING 20 years KNOW HOW

Atkomatic VALVE CO., INC.

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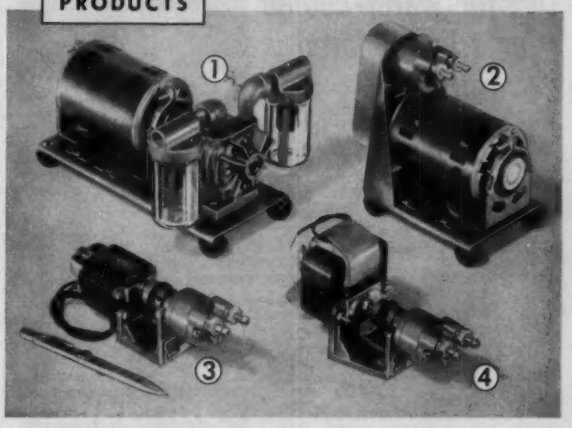
ROTARY AIR GAST PRODUCTS

NEW for 1960



TWO TYPES OF MINIATURE OIL-LESS GAST rotary vane VACUUM PUMPS and AIR COMPRESSORS

1. Model 1030-V110-206 Vac. Pump, 1/20 h.p. Up to 1 c.f.m.; to 15" vac.
2. Model 0330-V112-206 split phase 1/20 h.p. motor, .48 c.f.m. Up to 20" vac. or 15 p.s.i.g.
3. Model 0330-V102A-151 series wound motor. Up to .67 c.f.m. To 20" vac. or 10 p.s.i.g.
4. Model 0330-V110-202 shaded pole motor. Up to .35 c.f.m. To 20" vac. or 10 p.s.i.g.
5. (Below) Model 0630-P103 Compressor, up to .6 c.f.m. To 25 p.s.i.g. or 24" vac.

FOR ORIGINAL EQUIPMENT APPLICATIONS ON CONTROLS, INSTRUMENTS, BUSINESS MACHINES, LAB EQUIPMENT

Now — where space is very limited — you can provide moderate vacuum or pressure with one of these two types (3 series) of Gast semi-miniature Air Pumps.

They run entirely without oil. Carbon vanes lubricate themselves, producing a completely oil-free air blast or exhaust. Rotary design is simple, trouble-free and positive in air displacement.

The largest Model 1030 (1 above) delivers up to 1 c.f.m. running open at 3450 r.p.m. Model 0630 (5 below) has identical exterior, delivers up to .6 c.f.m. Smaller type 0330 (2, 3, 4 above) is shown with a choice of motors to suit various pump applications, both a.c. and d.c. With a rotor diameter smaller than a penny, Model 0330 produces up to .67 c.f.m. (open) at 6000 r.p.m.!

5

These "semi-miniatures" may solve a problem for you — investigate today!

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See Catalog in Sweet's Design File

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Circle 570 on Page 19

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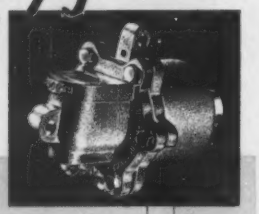

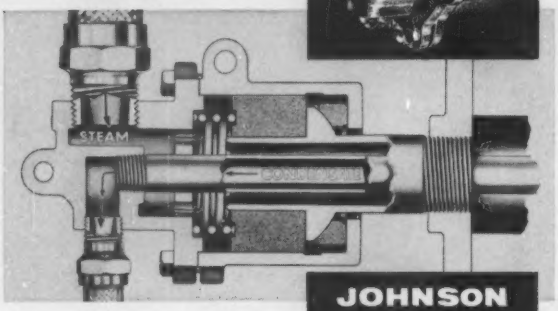

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Circle 571 on Page 19

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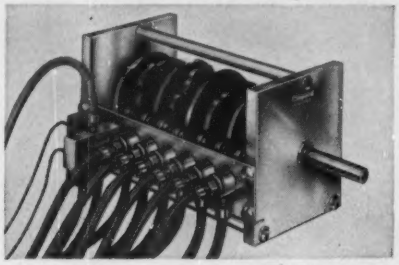

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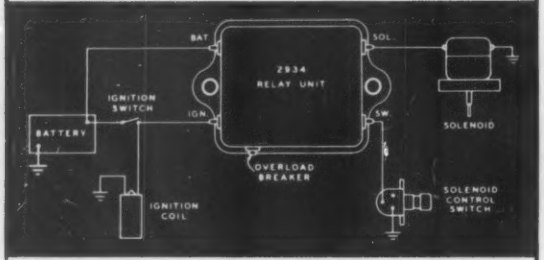
REMOTE CONTROL *for Synchro-Start* SOLENOIDS



The wiring diagram shows how the Model 2934 Relay Unit protects Synchro-Start Solenoids. It has been designed specifically with overload breakers to guard against burn-out in the event of external linkage jams.

As it carries only the relay coil current, a relative light duty pilot switch can be used. It also provides a means for keeping the main power leads as short as possible, thus assuring maximum power output from the solenoid.

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NBP

backtalk—

—Show Biz

Probably every man who has built up his bunions by standing "behind the counter" at a trade-show exhibit has wondered if it was worth the effort. He can be consoled by a recent survey of visitors of the Wescon Show (Western Electronic Show and Convention) held in Los Angeles last August. Here are some of the survey's findings, based on random interviews of 730 attendees:

- 93.5 per cent said that the convention had served to advance their knowledge of the industry.
- Over 88 per cent thought the exhibits would help them with their jobs.
- 89.6 per cent felt that the lectures and technical discussions served to advance the electronic art.

—Opportunities Knock

If you have a competitive nature, and if you've been working on problems involving miniaturization, arc welding, or steel castings, perhaps you can win yourself a prize.

To promote steel castings as an engineering material, to show technological progress made by the steel foundry industry, to encourage further progress, and to celebrate the industry's 100th anniversary, the Steel Founders' Society of America is sponsoring a Product Development Contest. Entries are to describe applications of steel castings in the light of such factors as cost, mechanical or metallurgical design, or redesign or conversion. Awards totalling $10,000 will be divided among 110 entrants; entries will be accepted through May of 1961. Write to Fourth Centennial Product Development Contest, Steel Founders' Society of America, 606 Terminal Tower, Cleveland 13, Ohio, for details.

The James F. Lincoln Arc Welding Foundation has an award program offering a total of $25,000 for 76 papers in two divisions, mechanical and structural. Papers must describe the use of arc-welded steel in designing a machine or machine component (or a structure or structural component). Judges will evaluate performance, appearance, and savings in cost and time made possible through welded design. Competition closes next July. The Foundation's address is P. O. Box 3035, Cleveland 17, Ohio.

The fourth annual competition of the Miniaturization Awards, sponsored by Miniature Precision Bearings Inc., has just been announced. The award, a bronze sculpture symbolizing miniaturization, will be presented to the individual, company, or organization that has made the year's outstanding contribution to furthering the concept of miniaturization. Deadline for entries is January 10, 1961, and information can be obtained from Miniaturization Awards Committee, P. O. Box 604, Keene, N. H.

—No Funny Business

Engineering, you may have noticed, is not a "fun" profession like, say, seismology or chiropody. We realize that the nature of the subject makes engineering situations hard to transform into graphical humor, and since we want to lighten your reading of MACHINE DESIGN with an occasional funny, we grab eagerly and hopefully when the mailman brings an envelopeful of cartoons. Once in a while he brings a real gem such as this one by Luther Scheffy, who has provided us with a good many

"Here's a rough sketch of the idea."

chuckles. In accepting this one, we admitted to Mr. Scheffy that it "caused us to laugh out loud." He wrote back that it was gratifying to him to hear this, because he feels this is the kind of cartoon cartoonists like but are apprehensive about sending to editors.

After this big buildup, we can only hope that your sense of humor is as warped as ours and that you, too, laughed out loud.

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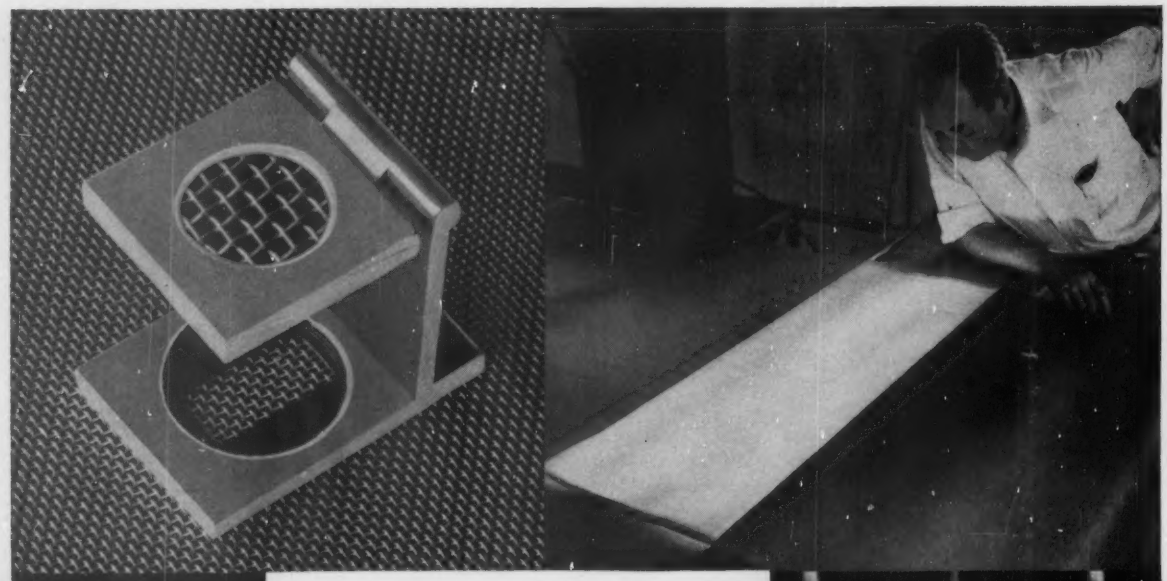

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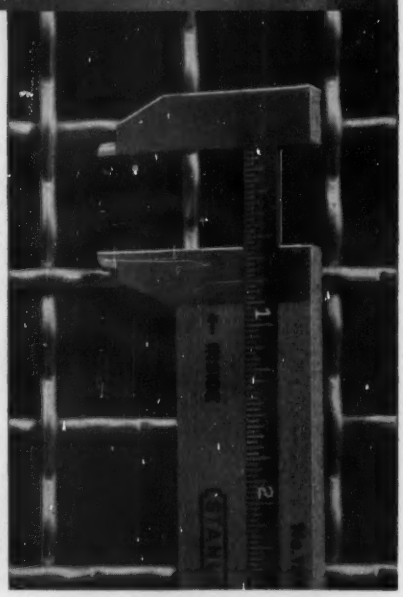

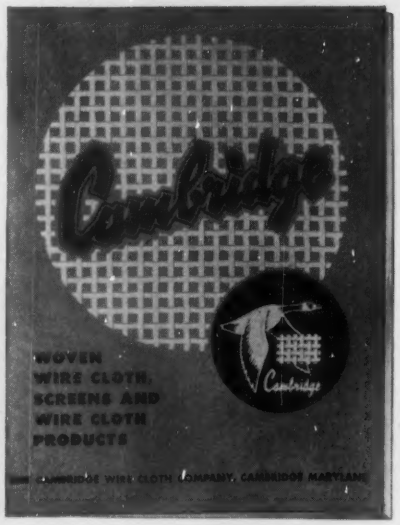

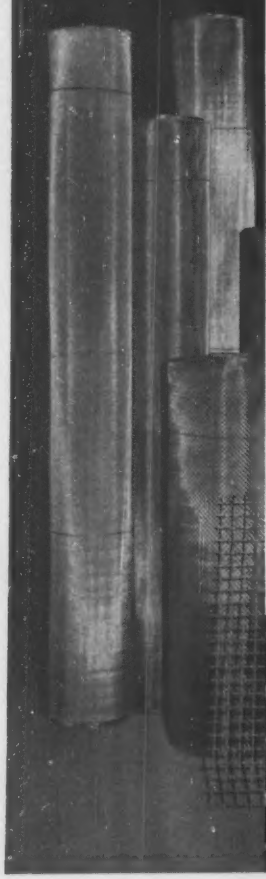

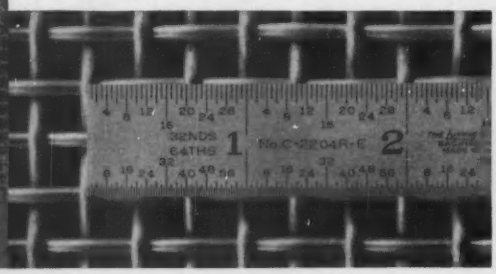

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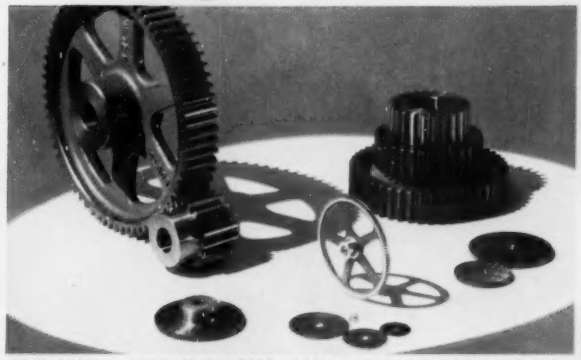

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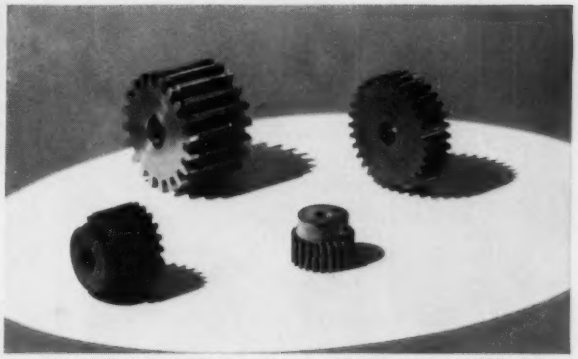

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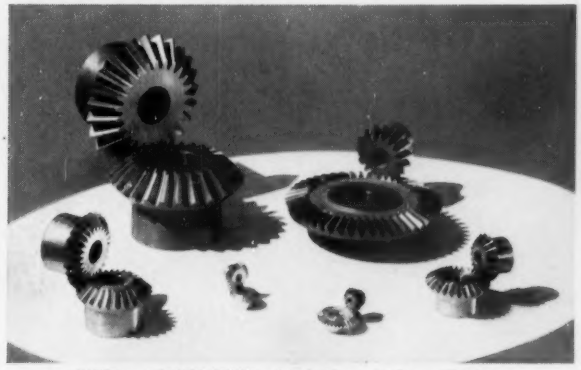

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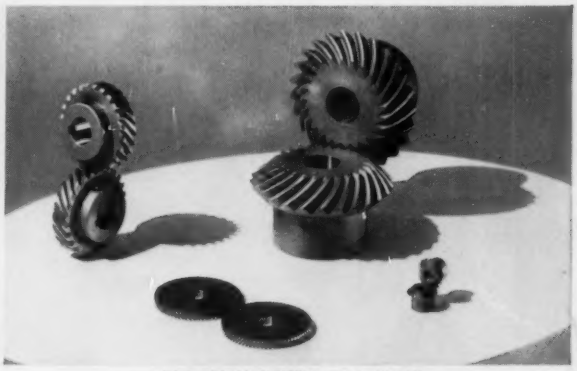

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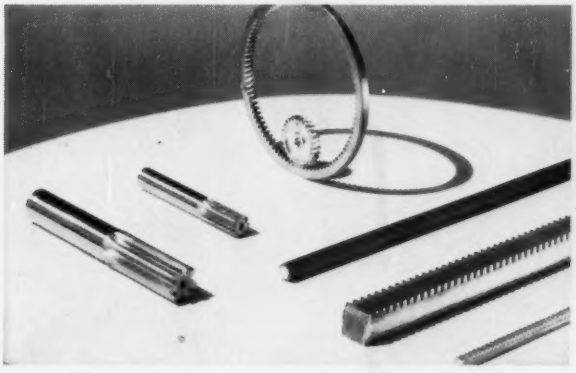

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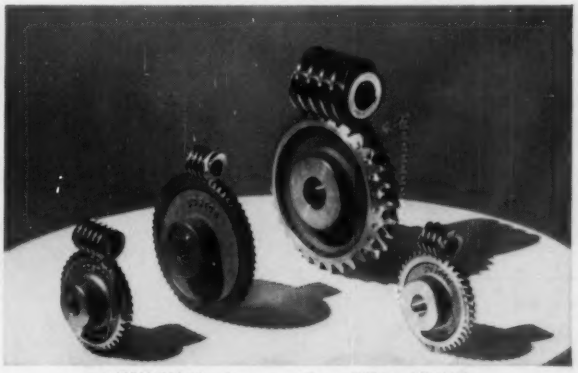

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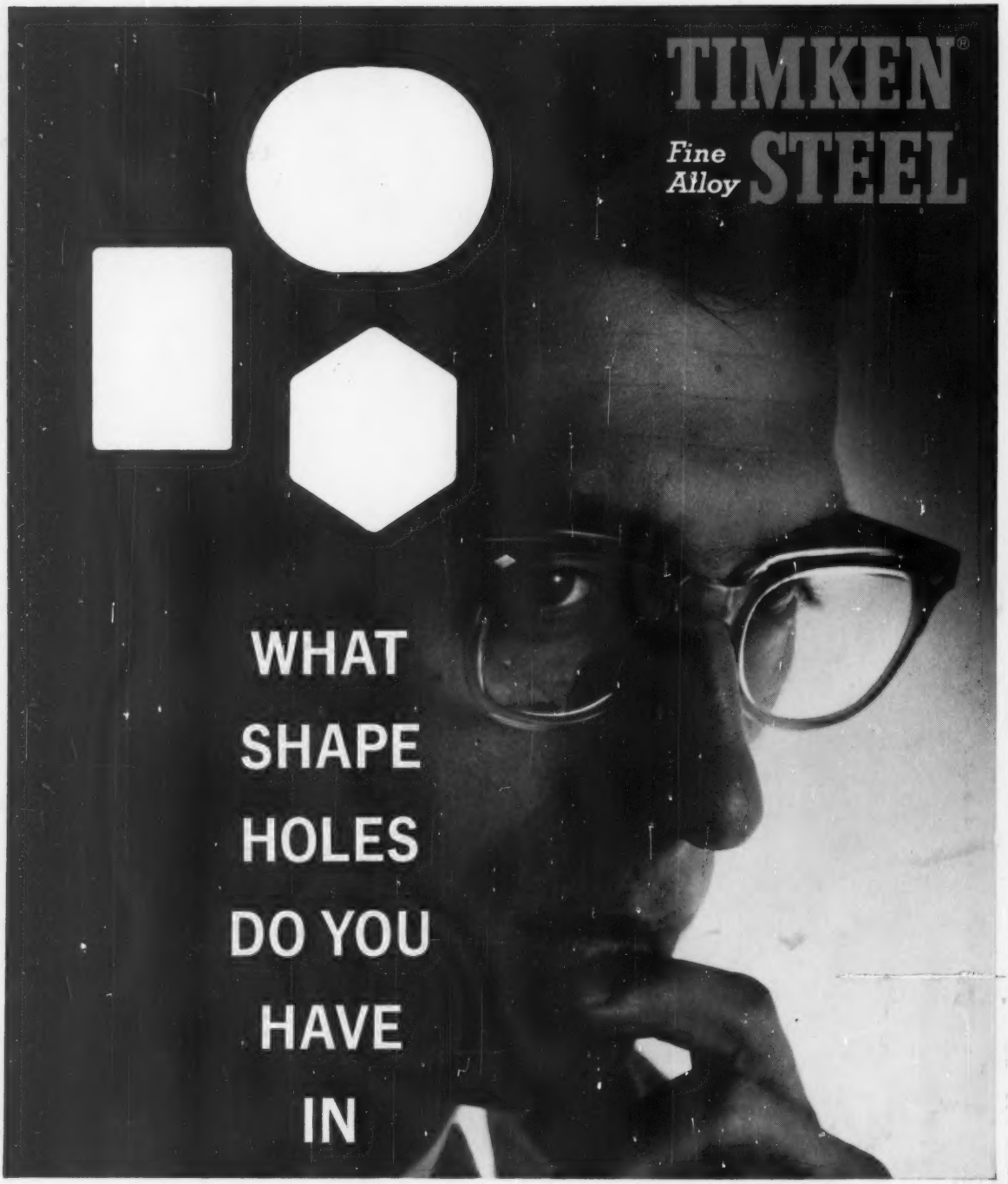

WHAT SHAPE HOLES DO YOU HAVE IN MIND?

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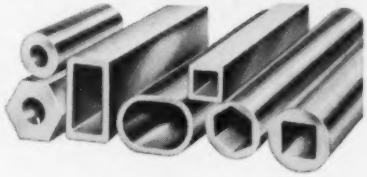

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